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JOURNAL

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Volume 42 October, 1926 Nos. 1 and 2

PROCEEDINGS OF THE TWENTY-FIFTH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE

WAKE FOREST, APRIL 30 AND MAY 1, 1926

The twenty-fifth annual meeting of the North Carolina Academy of Science was held at Wake Forest, April 30 and May 1, 1926. The meeting was called to order promptly at 10:30 a.m. by the Secretary, and Prof. Z. P. Metcalf was made acting chairman in the absence of President Givler and Vice-President Halverson. The reading of papers was begun and continued until 12:30, when the following committees were appointed:

Nominating—J. L. Lake, A. S. Wheeler, and C. S. Brimley.

Resolutions—H. B. Arbuckle, W. T. Wright, and J. B. Bullitt.

Auditing—L. H. Snyder, L. B. Rhodes, and H. T. Davis.

The Academy adjourned for luncheon.

The reading of papers was begun again at 2:30 p.m. with Vice-President Halverson in the chair, and continued until 4:30 p.m., when the Academy went into business session.

The minutes of the previous meeting were approved as published in the ELISHA MITCHELL JOURNAL.

The reports were called for from the following committees:

The High School Prize Committee. No report. The committee was discharged and its function taken over by the Committee on High School Science.

The High School Science Committee.

"The Committee met in the office of Dr. J. H. Highsmith of the State Department of Education, Tuesday afternoon, April 20.

The following were present: Cunningham, chairman, Wells, Heck, Highsmith, Wilson.

Reports were made by members of the Committee who attended the various district meetings of the N. C. E. A. during the past year. Dr. Wells attended the Fayetteville meeting, Prof. Wilson the one at Charlotte, Dr. Cunningham at Washington. Dr. Highsmith attended all of the meetings and reported for the science section of the Raleigh meetings.

In each case a live and worth-while program was reported, consisting of business meeting, papers on high school science, a talk or address by the visiting member of the North Carolina Academy of Science, and a round table discussion of problems.

On motion it was decided to ask Prof. Heck and Dr. Highsmith to arrange, if possible, with the Executive Committee of the N. C. E. A. to carry out a similar procedure again this year, it being understood that the committee of the Academy furnish a representative from the Academy, and that the Association take care of his traveling expenses.

It was the feeling of the Committee that the representatives of the Academy should also be given a place on the general program, as well as on the program of the science section.

It was also suggested that the representatives coöperate with the chairman of the district sections in arranging their programs, and, if possible, to prepare an exhibit of science work or materials."

(Signed) BERT CUNNINGHAM, *Chm.*
R. N. WILSON, *Sec.*

The report was adopted and the committee continued.

The Conservation Committee made a verbal report, which was adopted and the committee continued.

The Legislative Committee reported and, through its chairman, resigned. The resignation was accepted by the Chair for the Academy. A new committee is to be appointed.

The Publicity Committee reported and asked to be discharged and the committee discontinued. The report was adopted and the committee discontinued.

The Executive Committee reported as follows:

"The Executive Committee held a short meeting at luncheon at State College, May 2, 1925. It was moved and carried that the Secretary be

authorized to spend as much as $100 for stenographic help in the administration of his office. Several minor policies were discussed but no further action was taken.

The Executive Committee met in Raleigh on April 29 at 8:30 with the following members present, H. B. Arbuckle, Z. P. Metcalf (serving as proxy for J. O. Halverson), and B. Cunningham.

The Committee made the following recommendations to the Academy:

(1) That all bills as presented in the Treasurer's report be authorized and paid and that the report be printed when audited.

(2) That beginning with this meeting the Academy shall elect its representatives to the Council of the American Association biennially.

(3) That the Academy request Dr. W. C. Coker to represent it at the International Council of Plant Sciences.

(4) That the High School Science Committee take over the administration of the High School Science Prize, and that the special committee be discharged.

(5) That the Publicity Committee be discharged.

(6) That the Academy send greetings to the Kentucky Academy which meets May 1.

(7) That the Constitution be so amended as to provide for the election of the Secretary for a period of three years.

The recommendations were adopted.

The committee reported the following elected to membership:

George Garfield Ramsey, Prof. of Chem., Catawba College, Salisbury, N. C.
Walter James Wyatt, Jr., Instructor, Wake Forest College, Wake Forest, N. C.
Robert Sproul Carroll, Pres., Highland Hospital, Asheville, N. C.
Howard O. Smith, Prof., Guilford College, Guilford, N. C.
Harrison D. Panton, Consulting Engineer, Odd Fellows Bldg., Raleigh, N. C.
Theodore A. Werkenthin, Solar Refining Co., Lima, Ohio.
Ora Clara Bradbury, Prof. of Biology, Wake Forest College, Wake Forest, N. C.
Charles DeWitt Colby, Box 124, Asheville, N. C.
Rufus H. Pickens, Clemmons, N. C.
Julius E. Willoughby, Chief Engr., A. C. L. R. R. Co., A. C. L. Building, Wilmington, N. C.
Ralph P. Seward, Prof., Catawba College, Salisbury, N. C.
Frederick H. Claridge, Asst. Forester, Dept. of Conservation and Development, Raleigh, N. C.

John Henry Davis, Jr., Asst. Prof. Biology, Davidson College, Davidson, N. C.
Jules Freund, M.D., Von Ruck Research Lab., Asheville, N. C.
Dr. Chas. Alexander Anderson, Burlington, N. C.
George Herbert Cole, Prof. Physics, Guilford College, Guilford, N. C.
Miss Katie King, Greenville, N. C.
G. W. Rhodes, Principal and Teacher of Sci., Bath, N. C.
Samuel F. Hildebrand, Ph.D., Director U. S. Fisheries, Biological Station, Beaufort, N. C.
Clarence H. Brannon, Asst. Ext. Entomologist, State College, Raleigh, N. C.
H. H. Braxton, Assist. Botany, U. N. C., Chapel Hill, N. C.
L. E. Bush, Dept. of Mathematics, U. N. C., Chapel Hill, N. C.
Jeff Bynum, Geology, U. N. C.,, Chapel Hill, N. C.
W. M. Elliott, Mathematics, Duke University, Durham, N. C.
H. E. Fulcher, Dept. Math., Davidson College, Davidson, N. C.
Miss Annie Gordon, Biology, Flora McDonald College, Red Springs, N. C.
Louis Dienes, M.D., 63 Albemarle Rd., Asheville, N. C.
Clarence Davis Schiffman, Chemistry, 112 N. East St., Raleigh, N. C.
Donald B. Anderson, Prof. Botany (Asst.), State College, Raleigh, N. C.
F. A. Lee, Instructor in Mathematics, State College, Raleigh, N. C.
Prof. J. H. Mourane, Chemistry, High Point College, High Point, N. C.
Prof. D. M. Arnold, Mathematics, Duke University, Durham, N. C.
Dr. W. M. Nielson, Physics, Duke University, Durham, N. C.
Dr. J. S. Buck, Chemistry, Duke University, Durham, N. C.
Mr. W. A. Watt, Sec. Pilot Life Ins. Co., Greensboro, N. C.
Miss Minnie Kopf, Home Economics, Guilford College, N. C.
Miss Dorothy Wolf, Biology, N. C. C. W., Greensboro, N. C.
Dr. G. R. Shelton, Ceramic Engineering, State College, Raleigh, N. C.
Mr. Harold Whitehurst, Principal, Cove City School, New Bern, N. C.
Miss Velma Matthews, Grad. Student in Botany, U. N. C., Chapel Hill, N. C.
Mr. H. T. Thompson, Asst. in Botany, U. N. C., Chapel Hill, N. C.
Prof. S. O. Trentham, Biology, Mars Hill, N. C.
Mr. J. L. Stuckey, Geology, U. N. C., Chapel Hill, N. C.
Mr. J. B. Linker, Mathematics, U. N. C., Chapel Hill, N. C.
Prof. R. F. Poole, Plant Pathology, State College, Raleigh, N. C
Mr. V. A. Hoyle, Mathematics, U. N. C., Chapel Hill, N. C.
Miss Verdie Snyder, Graduate Student Biology, Duke University, Durham, N. C.

The committee reported that it received the resignation of President Givler, and thought best to refuse it, but relieved him from delivering a Presidential Address. Also, effort was made to secure an outstanding man to speak, but this was unsuccessful."

The report of the Executive Committee was adopted.

The Treasurer's report was called for and presented as follows:

Financial Statement

Receipts		Expenditures	
Balance on hand	209.63	Balance Secretary's Commission 1924–25	11.30
Dues 1924–25	70.00	Postage	36.08
Chemists Program 1925	5.00	Secretary Commission	29.00
Dues 1925–26	329.50	Stenographer	66.50
Chemists Program 1926	5.00	E. M. Journal	175.00
	619.13	Miscellaneous	118.44
			436.32
		To Balance	182.81
			619.13

Detail of Miscellaneous Expense

Posters, Placards for Raleigh Meeting	8.10
Express on Reprints	1.12
Secretary's Expense Raleigh Meeting	7.45
Savings Account	9.64
Rubber Stamp	0.65
Reprints of Constitution, etc	26.48
Multigraphing	29.25
Math. Section Expense	10.00
Dues Refund to Secretary	2.00
1000 Programs	23.75
	118.44

Comparison	1924–25	1925–26
Savings Account	340.36	362.96
Checking Account	209.63	182.81
	549.99	545.77
To Balance		4.22
		549.99

The above report was made as of April 28.

Submitted by

BERT CUNNINGHAM, *Secretary-Treasurer.*

Audited by

L. H. SNYDER,
H. T. Davis,
L. B. Rhodes.

The Treasurer's report and the recommendations were adopted.

The Auditing Committee reported that it had examined the Treasurer's books and found them correct. The report was adopted and the Treasurer instructed to print the financial statement.

The Nominating Committee made the following nominations:

For President—Dr. Bert Cunningham, Duke University.

For Vice-President—Dr. F. E. Rice, State College.

For Secretary-Treasurer—Dr. H. R. Totten, University of N. C.

For Member of Executive Committee for 3 years—Dr. J. W. Nowell, Wake Forest.

These were elected by acclamation.

The Resolutions Committee reported as follows:

"Whereas Miss Gertrude Mendenhall, a faithful member of this Academy, has died during the past year: Be it resolved that the members of the Academy place on record an expression of our sorrow and sense of loss and that the Secretary of the Academy be instructed to convey to her family the sympathy of the Academy.

"Whereas the present President of our Academy, Prof. J. P. Givler, has been prevented by serious illness from attending this meeting, we desire to express to him our very deep grief at the necessity of his absence and our appreciation of his valuable services to the Academy and our earnest hope for his speedy recovery.

"Resolved that the Academy express their appreciation of the courtesy and efficient service rendered by the Trans Lux Co.

"Resolved that the Academy extend to the Faculty of Wake Forest College and to our other hosts at Wake Forest our sincere thanks and appreciation for their courtesy and hospitality at this meeting."

The report was adopted.

Upon the call for other business, Dr. B.W. Wells presented the following resolution:

"The North Carolina Academy of Science desires to reiterate that if the present rate of progress and enlightenment in the State of North Carolina is to be maintained and advanced, it is absolutely necessary that all those hypotheses, theories, laws and facts which constitute the legitimate content of any field of study, may be dealt with at any time by any teachers."

"This was referred to a committee consisting of W. C. Coker, B. W. Wells and B. Cunningham with instructions to report after the next paper. The resolutions as presented by this committee follow:

"The North Carolina Academy of Science desires to reiterate that if the present rate of progress and enlightenment in the State of North Carolina is to be maintained and advanced, it is absolutely and unqualifiedly necessary that all those hypotheses, theories, laws and facts which constitute the legitimate content of any field of study, may be dealt with at any time by any teachers.

"The Academy goes on record as endorsing most emphatically the stand of Dr. H. W. Chase and Dr. W. L. Poteat on the freedom of thought and teaching."

The report was unanimously adopted by rising vote.

The Academy then adjourned for the social hour and supper en masse at the hotel as guests of Wake Forest College.

The Academy reconvened at 8:15 p.m., when President Poteat in a few well chosen words welcomed the Academy. Vice-President Halverson of the Academy responded for that organization. The Presidential Address was omitted on account of the illness of President Givler. The reading of papers was again resumed, and continued until 10:00 p.m., when the Academy adjourned to meet in sections on the following morning.

The Academy convened in sections Saturday morning, with Dr. Poteat and Dr. Metcalf presiding over the non-section group, Dr. Derieux over the physicists, Dr. Rice over the chemists, and Dr. Robison over the mathematicians.

The following group officers were elected: Physics, Dr. J. B. Derieux, president; Dr. W. M. Nielson, vice-president; Dr. C. C. Hatley, secretary-treasurer. Chemistry, Dr. J. T. Dobbins, chairman; Dr. A. S. Wheeler, councillor; Mr. L. B. Rhodes, secretary-treasurer. Mathematics, A. W. Hobbs, President; W. M. Elliott, Secretary.

In addition to the usual business transacted by the Physics Teachers Association, the following resolution was adopted:

"The members of the North Carolina Physics Teachers Association in meeting assembled, wish to put themselves on record as deploring and opposing any movement to forbid the teaching of science in the schools of North Carolina or abridge the freedom of investigation and discussion of facts and theories in every branch of science. We believe it to be our right and duty to use our God-given intelligence in studying the facts of His universe and to find and follow his truth wherever it may lead."

A short meeting of the Executive Committee was held at noon May 1, 1926, at Wake Forest. In the absence of the newly elected Secretary, the retiring Secretary was requested to take the minutes and transmit them to the Secretary elect.

It was moved and carried that the usual appropriation not to exceed $100.00 should be made for stenographic aid to the Secretary.

It was moved and carried that the next meeting be held at Davidson College.

It was moved and carried that the retiring Secretary be allowed to further draw on the appropriation for secretarial aid not to exceed $10.00. This still allows an unexpended balance to revert to the general fund.

In view of the fact that the recommendation of the Executive Committee, adopted by the Academy, providing for the election at this meeting of the Academy a representative to the American Association, was overlooked, the committee appointed the President elect, over his protest, for the current year.

The following papers were presented. (Those marked with an * appear in full in this issue; those marked x are abstracted in this issue; for those unmarked no abstracts have been received. The one marked † will appear in the Journ. Amer. Chem. Society.)

**Embryology of the Carnation Mite.* O. C. BRADBURY.
**Studies on Deodorizing Fish Oils.* E. E. RANDOLPH.
The Incubation of Hen Eggs Under Increased Atmospheric Pressure. BERT CUNNINGHAM.
x*A Comparison of Chicks Incubated for Five Days Under Increased Pressure and Normal Pressure.* MISS V. E. SNYDER.
Advantages of a Behavioristic Treatment of Perception. J. F. DASHIELL.
Velocity of Sound in Closed Pipes. JAMES L. LAKE.
Climate and Civilization in Central America. C. COBB.
In Praise of Ignorance. W. L. POTEAT.
x*Human Blood Groups: Their Inheritance and Racial Significance.* L. H. SNYDER.
**Other Water Molds and Pythiums from the Soil.* W. C. COKER.
Method Used in Measuring the Intensity of Gravity. J. B. DERIEUX.
Intensity of Gravity at Raleigh. J. S. MEARES.
Studies in the Triassic of the Deep River Basin. W. F. PROUTY.
**Variation of Protein Content of Corn.* H. B. ARBUCKLE AND O. J. THEIS, JR.

**The Drought of 1925.* LEE A. DENSON.
**Non-Protein Antigens of Bacteria.* J. FREUND.
The Structure of Some Young Dog Embryos. W. C. GEORGE.
A Southern Upland Bog Succession. B. W. WELLS.
A Preliminary Survey of the Sponge Fauna of Tortugas, Fla. H. V. WILSON.
**The Male Genital Tube of Some North Carolina Coccinellidae.* J. W. WILSON.
**Revised List of the Amphibians and Reptiles of North Carolina with a Key to the Species.* C. S. BRIMLEY.
Some Ecological Aspects of the Vegetation on Smith's Island. H. L. BLOMQUIST.
Present Status of High School Science. J. HENRY HIGHSMITH.
x*Soil Classification.* WM. B. COBB.
**The Relation of Temperature, Light and Humidity to the Behavior and Longevity of a Joint-Worm Parasite.* C. H. BRANNON.
x*A Self Correcting Formula for the Calculation of Rock Thickness.* J. H. SWARTZ.
Problems of Scientific Research in the Field of Sociology. C. C. TAYLOR.
The Reaction of Eristalis tenax to Light from Two Sources. J. L. WIERDA.
x*The Colors of Silicate Minerals.* G. R. MACCARTHY.
Reducing Substances in the Blood of Some Crustacea. MISS MARY FRANCES SEYMOUR.
x*Financial Value of Forest Cover in Protecting Reservoirs for Power.* W. W. ASHE.
**Leaf pot of Leather-leaf Fern.* F. A. WOLF.
x*The Age of the Universe.* J. H. SWARTZ.
A Chinese Civilization Based on Agriculture. C. COBB.
Spanish Oak. Black Pine Type. W. W. ASHE.
x*The Occurrence of an Ova-Testis in Bufo terrestris.* BERT CUNNINGHAM AND CLARA BECTON.
Chinese Peteroglyphs and Ideagraphs in Arizona. C. COBB.
x*The Chattanooga Shale of Southwestern Virginia.* J. H. SWARTZ.
Compatible Differential Systems. W. W. ELLIOTT.
A Theorem Related to Hademard's Determinant. G. M. ROBISON.
x*Involutory Collineations Belonging to a Pencil.* E. T. BROWNE. [See Abstract under Proc. E. M. Sci. Soc.[
x*Method of Solving Simultaneous Quadratic Equations.* L. E. BUSH.
Euclid's Fifth Postulate. A. HENDERSON.

x*High Frequency Electrical Measurements with the Vacuum Tube.* J. D. FINKLEA.

Structure of the Atomic Nucleus. A. H. PATTERSON.

x*The Recovery of Selenium from the Effect of X-rays.* P. H. CARR.

x*The Emission Spectrum of CO_2 in a Bunsen Burner.* E. K. PLYLER.

x*The Electrodeless Discharge in Iodine Vapor.* J. F. DAUGHERTY.

x*The Formation of Negative Ions in Mercury Vapor.* WALTER M. NIELSEN.

The following papers were presented to the North Carolina section of the American Chemical Society.

The Present Status of Vitamins. J. O. HALVERSON.

Electrometric Titrations of Copper Solutions. J. M. BELL.

**Cotton Classification.* W. M. MEBANE AND F. C. VILBRANDT.

†*Analytical Separation of the Platinum Metals.* S. C. OGBURN, JR.

Latent Heat of Fusion of Some Nitrotoluenes. H. D. CROCKFORD.

Lubricating Oils for Internal Combustion Engines. J. C. SIMMONS, W. M. LOFTON AND F. C. VILBRANDT.

Electro-plating Aluminum. F. F. JONES AND F. C. VILBRANDT.

**Sodium for Potassium in Technical Analysis.* A. R. SMITH AND F. C. VILBRANDT.

**Utilization of North Carolina Coals.* F. C. VILBRANDT.

2-Amino-6-nitro-p-cymene. A. S. WHEELER AND C. R. HARRIS.

2-6-Diamino-p-cymene. A. S. WHEELER AND E. DEW. JENNINGS.

2-Amino-5-nitro-p-cymene. A. S. WHEELER AND F. B. BROOKS.

The following abstracts have been received:

A Comparison of Chicks Incubated for Five Days Under Increased Pressure and Normal Pressure. MISS V. E. SNYDER.

Chicks incubated under pressure by the method described by Cunningham were considerably in advance of check chicks incubated simultaneously in the same incubator. Conclusions are based on histological and organological studies.

Human Blood Groups: Their Inheritance and Racial Significance. LAURENCE H. SNYDER.

A study of the inheritance of the blood groups in 200 families, involving 1095 individuals, is given, which, with the mathematical con-

siderations of the mass data, indicates that the blood groups are inherited as a series of three multiple allelomorphs. This considerably changes previous ideas as to the medico-legal application of the groups, and their bearing on racial relationships.

A detailed study of the group proportions of American Indians is given, indicating that full-blooded Indians are all group I. This is apparently the primitive group, other groups among Indians being due to white admixture. Other isolated races, such as Filipinos, Icelanders, Australians, etc., also show this same high proportion of group I.

Evidence is presented for the normal distribution of the groups in cases of insanity, epilepsy and feeblemindedness.

The group proportions of several races are given for the first time, and the available data from all the races of the world which have been studied are collected and correlated.

A classification of races, based on the three inherited factors A, B, and R, is given. Some remarkable relationships are shown by this correlation chart. The application of the blood group data to racial relationships and origins is discussed.

Soil Classification. WM. B. COBB.

Until recent years the classification of soils has been based on dividing them into groups based on geological origin and on dividing these groups into series and types based on soil characteristics. The work of the Russian soil scientist, Glinka, has shown that the broader groups of soils should be separated on the basis of the climatic condition under which the soils have developed. Glinka pointed out that all mature soils regardless of parent materials or geological processes of formation are similar when they have been subjected to similar climatic conditions. All mature soils of a given region have a characteristic profile consisting of three zones, the zone of leaching, the zone of accumulation, and the zone of parent material. Each of the upper zones is typically made up of a definite number of layers with definite characteristics which are due to climatic conditions. Young soils do not have this typical profile and owe their characteristics mainly to their parent materials.

These facts form the basis of most systems of soil classification now in use.

A Self Correcting Formula for the Calculation of Rock Thickness. J. H. SWARTZ.

Although one of the most essential features of geological field work,

traverse calculations of rock thickness have received entirely inadequate treatment in all but two papers. Even in these two articles a number of troublesome factors have been neglected. So many complications can enter such calculations that a self correcting formula is seriously needed. The following formula,

$$t = D\cos\sigma\cos\beta\sin\delta + D\sin\sigma\cos\delta$$

in which t is the thickness of the rocks traversed, D the traverse distance, σ the slope of the surface along which the measurement is made, β the angle between the dip direction and the traverse direction, and δ the dip, may easily be derived.

Two simple rules are to be observed in making the calculations:

1. Always measure β through 360° for the dip *direction* to the traverse *direction*.

2. Let σ always be *positive* when going *uphill* and *negative* when going *downhill*.

When these are followed, t will always be positive when ascending and negative when descending stratigraphically, regardless of the complexity of the factors involved.

The Age of the Universe. J. H. SWARTZ.

If we assume that the energy radiated into space by the stars comes chiefly from the conversion of mass into energy as held by Einstein, Jeans, Eddington, Russell, and others, and that the differences in the average mass of stars in different stages of development are due to such mass conversion, we may immediately calculate the time required for a star to pass through any given stage of its life history from the formula

$$t = \frac{\Delta M\, c^2}{2.572.10^{-4} M^{1/3} \rho^{-2/3} T^4}$$

in which t is the time required to pass through a given stage of a star's development, ΔM the loss in mass during that stage (expressed in grams), c the velocity of light, and M, ρ, and T the average mass, density, and absolute temperature respectively of stars in that stage.

Calculations based on this formula give the length of time required for Russell's dwarf sequence (Eddington's "main sequence") as 66 trillion years. While not accurate, because of the uncertainty of the stellar data which must be used, the result indicates the order of magnitude, at least, of the time involved in stellar evolution.

The Chattanooga Shale of Southwestern Virginia. J. H. SWARTZ.

The key to the Chattanooga shale problem, which has puzzled geologists for nearly three quarters of a century, lies in southwestern Virginia. A study of the shale of that locality, made possible by a grant from the Graduate Research Fund of the University of North Carolina, has shown that the Virginian equivalent of the Chattanooga shale, the Big Stone Gap shale, is overlain by typical Devonian deposits carrying Chemung fossils, 6 miles northeast of Mendota. It is thus definitely Devonian in age. North of Mendota the Big Stone Gap shale becomes more and more arenaceous and is accompanied by an increasing number of sandstone beds as far as it can be definitely traced. An arenaceous black shale is found near Saltville at the base of the Chemung, accompanied by much sandstone and sandy shale. It appears to occupy the same stratigraphic horizon and is probably a further extension of the Big Stone Gap shale, which is thus recognized much further north than it had previously been supposed to exist. Incomplete data appears to indicate that the shale represents the lower part of the Chattanooga shale of the type locality near Chattanooga, Tennessee.

The Colors of Silicate Minerals. G. R. MACCARTHY.

Most silicates owe their color to iron. This iron is usually in the form of a ferro-ferric compound in part, and in part in the form of a ferrous compound. Hydrous ferro-ferric compounds are *blue*. The usual color of ferrous silicates is *green*. In artificial silicates greens are produced only by mixtures of *yellow ferric* and *blue ferro-ferric* compounds, with the ferric molecule in excess. In green minerals the ferrous molecule is usually in excess. It is suggested that an originally colorless ferrous silicate may be partially oxidized, a slight amount of a blue ferro-ferric and a large amount of a yellow ferric compound forming. An ordinary green silicate would then contain three types of molecules: a colorless ferrous, a blue ferro-ferric, and a yellow ferric.

Financial Value of Forest Cover for Protecting Reservoirs for Power. W.W. ASHE.

The available water power of the southeastern states is limited. On account of the great fluctuations in stream flow, the maximum utilization of run-off and a uniform delivery of electric power can be secured only by means of costly reservoirs to make storm water supplement the dry season flow. In North Carolina about one-half of the water power resources is already in use, and the recent rapid industrial prog-

ress of the state has been largely determined by this cheap power. The complete development of all the power will probably be followed by a sharp falling off in the rate of development. For this reason it is extremely desirable that all reasonable means be employed to protect the sources of power and render available every possible kilowatt. Reservoirs in the southeast, if located upon watersheds having upon them considerable areas of cleared lands, are exposed to loss in storage capacity through deposits of silt which are the result of erosion from exposed or naked soil. Many reservoirs on the Catawba and Chattahoochee rivers and upon other streams have already silted flush. When this has taken place a basic and unreplaceable resource has been destroyed. Engineers in this region may determine the life of a reservoir and base charges and the value of the investment upon the period of usefulness. If the utility value of a reservoir decreases through silting at the rate of one-fortieth of its storage capacity a year, its capital value as an investment decreases proportionately. If, through reduction in erosion, the loss in storage capacity can be reduced so that its utility value is so extended that its utility value declines at the rate of only one-eightieth a year, the initial capital value is more than doubled. Under such conditions it would be profitable for the stockholders to expend in forest planting or in protection, as a means of reducing erosion, such an amount of money in excess of the capital value of the forest land and growing stock, as represents the present value of the prolonged utility value of the reservoir.

That is, if at the end of 40 years a reservoir which under normal conditions would have only one-half of the initial storage capacity and a capital value of $2,000,000 would have as a result of protection three-fourths of its storage capacity and a capital value of $3,000,000, it would be advantageous for its owners to expend, for securing this result, such a sum of money as compounded at current rate of interest would not exceed $1,000,000 in 40 years. Where forest cover furnishes the best means of securing such protection, this amount could be expended above and in addition to the investment value of the forest land and its growing stock, based upon the determination of the quality site.

The Occurrence of an Ova-Testis in Bufo terrestris. BERT CUNNINGHAM AND CLARA BECTON.

Without entering into a discussion of the literature concerning Bidder's organs, the authors wish to call attention to the occurrence of typical ovarian follicles embedded in testicular tissue of the toad *Bufo*

terrestris (formerly *lentiginosus*). The specimen was a fully matured male individual as determined by external features. The cysts were apparently filled with mature spermatozoa. The two ova (?) were embedded near the center of the tissue. The observation was a chance once, since the tissues of a number of toads were being prepared for cytological study. Determination of the species was made by Mr. C. S. Brimley, to whom thanks are due.

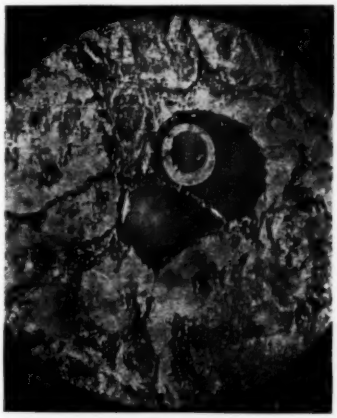


FIG. 1

Method of Solving Simultaneous Quadratic Equations. L. E. BUSH.

The solution of simultaneous quadratic equations by the method of substitution generally involves the solution of a quartic. Every quadratic equation in two variables represents a conic. It is possible to form the equation of the one-parameter family of conics on the four intersections of two given conics. Belonging to this family of conics are three degenerate hyperbolas, whose parameters can be found by solving a cubic equation. Using the parameters thus found, the equations of the degenerate hyperbolas can be formed, and each factored into a pair of straight lines. Solving certain pairs of these straight lines simultaneously leads to the four solutions of the original set of equations.

Certain cases in which two or more of the intersections coincide are dealt with, and an illustration of the method given.

High Frequency Electrical Measurements with the Vacuum Tube. J. D. FINKLEA.

A description of some of the methods of measuring high frequency currents, voltages, and phase angles by means of the three-electrode vacuum tube is given. By biasing the grid of the tube so that the plate current is reduced to zero the peak value of any unknown added alternating voltage can be found by measuring the additional grid bias necessary to again reduce the plate current to zero. Currents are measured by their voltage drops across a low resistance, a vacuum tube amplifier being used in the plate circuit to permit the measurement of the low voltages involved. If two equal capacity condensers are connected in series between two unknown alternating e.m.f.'s, the absolute potentials of the three junctions as measured by this method can be used vectorally to obtain the phase relations. Examples of its uses are given in respect to radio frequencies.

The Recovery of Selenium from the Effect of X-rays. P. H. CARR.

It has long been known that light, X-rays, Beta rays, and Gamma ray produce a change in the electrical resistance of selenium. Although it has been noted by many that the effect of these stimuli and the recovery from them is not instantaneous, very few investigators have studied the problem. However, it has been found that the recovery of selenium from the effect produced by light is a function of the duration of exposure to light. In this paper an attempt is made to show that the same holds true for the recovery of selenium from the effect of X-rays. Curves of recovery are shown and compared with curves obtained by others working on the recovery from light.

It is also observed that the water content of the selenium plays some part in the time of recovery. Although this has not yet been studied carefully, it seems that a large amount of water or the near absence of water in the selenium cell tends to increase the time of recovery immensely.

The Emission Spectrum of CO_2 in a Bunsen Burner. E. K. PLYLER.

Regions of maximum intensity have been previously found by other observers at 2μ, 2.73μ, 4.40μ and 14.7μ. With these values it is not possible to build up a harmonic series. A new weak emission band has been found at 6.8μ. This makes a harmonic series with the other bands. The band at 4.40 is slightly out of position, but this is probably due to its change in position with temperature.

The Electrodeless Discharge in Iodine Vapor. J. F. DAUGHERTY.

The electrodeless discharge is one produced in a bulb without electrodes by electromagnetic induction. An interrupterless X-ray transformer is used to excite an oscillatory circuit. In the oscillatory circuit there is a coil of seven coplanar turns of copper ribbon. This serves as the primary and the bulb some 12 cm. in diameter containing only iodine composes the secondary.

In tubes excited in this way two distinct types of discharge were observed in iodine. The first discharge, produced when the bulb and contents are at room temperature, was a yellowish glow filling the whole bulb. As the temperature is decreased this discharge takes the form of a ring just inside the bulb in the plane of the coil. This type of discharge gives a continuous spectrum with a broad absorption band in the green region. A spectrum of this kind is associated with the gas in a molecular state.

When the temperature of the bulb and its contents is between $-5°$ and 5°C. the second type of discharge takes place. This second discharge is of the ring type. It is a very brilliant green with a pink border. The pink border extends in toward the center of the bulb, a fact which is easily explained if one assumes that the vapor in this region is in a lesser degree of dissociation than that at the periphery of the bulb. This discharge gives a bright line spectrum.

The Formation of Negative Ions in Mercury Vapor. WALTER M. NIELSEN.

The method used is similar to that of Mohler.[1] Electrons, projected along the axis of a tube between two plates were prevented from scattering by a magnetic field of 350 gauss parallel to the axis of the tube. Negative ions formed by the attachment of an electron to an atom or to a molecule were removed by suitable potentials applied to the side plates. The remainder of the current reached a circular plate at the end of the tube. With a small field between the side plates, the negative ion current was just barely observable (1×10^{-10} amperes). With higher fields the ion current increased enormously, approaching saturation when the potential difference between the side plates was increased to between 3 and 4 volts. In this report the ion currents were of the order of 9×10^{-9} amperes. The total current was of the order of 1×10^{-7} amperes.

[1] F. L. Mohler. Phys. Rev. **26**: 614-624. 1925.

The ratio between the negative ion and total current decreases with increase in the driving potential for low voltages, but increases at 2.7, 4.7, 5.5, and 8.8 volts. The decrease at low potentials is similar to the results of Mohler in other gases and vapors. The cause of the break at 2.7 volts is not known. The breaks at 4.7, 5.5, and 8.8 volts are believed to be associated with the electronegative properties of the mercury atom having an electron in a metastable orbit. The total current rises rapidly with increase in the driving potential and decreases at 4.9 and 6.7 volts.

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY, OCTOBER 13, 1925, TO MAY 11, 1926

The Elisha Mitchell Scientific Society, composed of faculty and advanced students from the scientific departments of the University, numbered, for the year 1925–1926, 184 members (65 active and 119 associate). The officers of the society were: *President,* H. R. Totten; *Vice-President,* Thorndike Saville; *Permanent Secretary,* J. M. Bell; *Recording Secretary,* E. T. Browne; *Editors of the Journal,* W. C. Coker, Collier Cobb, and J. M. Bell. Fifteen papers were presented at the eight meetings held during the year. Of these, thirteen were presented by members of the faculty of the University, one was presented by an advanced student in chemistry, and one by a member of the Corps of Engineers, U. S. Army.

282ND MEETING, OCTOBER 13, 1925

W. DEB. MACNIDER—*The Influence of Pregnancy on the Stability of the Acid-Base Equilibrium of the Blood.*

These studies have extended over a period of eleven years. Seventy-four pregnant dogs of various age periods and at different stages of gestation have been studied concerning their ability to maintain during pregnancy a normal acid-base equilibrium of the blood.

Sixty-eight non-pregnant animals which have fallen in the same age groups have served as controls.

The conclusion from these studies is as follows:

"1. The acid-base equilibrium of the blood, as indicated by the alkali reserve of the blood, remains constant in non-pregnant animals at different age periods. This statement does not imply that the acid-base balance of such animals at different age periods is a stable balance.

2. In pregnant animals, in same age pregnancies as control animals, there may develop an instability of this equilibrium which is either associated with the occurrence of a renal injury and which may be looked upon as a retention phenomenon, or rises independent of such an injury. In this latter group of animals, the disturbance in the equilibrium increases in frequency and is earlier in its appearance in the gestation period as the age of the organism increases.

3. In old and in senile pregnancies, some physiological mechanism other than that of the kidney becomes unable to stabilize the acid-base equilibrium of the blood with the result, that as the pregnancy advances, this physiological state of the organism (gestation) becomes pathological."

4. The suggestion is made that these observations may explain some types of pregnancy toxemia.

W. C. COKER—*Some Remarkable New Fungi from Chapel Hill Soil.*

This was a report on a thesis by Mr. J. V. Harvey, entitled *A Study of the Water Molds and Pythiums Occurring in the Soils of Chapel Hill,* which appeared in full in the Mitchell Journal **41:** 151, pls. 12–19. 1925.

283RD MEETING, NOVEMBER 10, 1925

E. V. KYSER—*Application of Hydrogenated Oils to the Production of Transparent Soap.*

The purpose of this paper was to present the possibility of the use of materials which have not been generally utilized in the production of transparent soaps. Formerly it was thought that only tallow, cocoanut oil and castor oil could be used successfully for this purpose. We found that by using a hydrogenated vegetable oil having a melting point between 58° and 60°C. in the proper proportions in the formulae, that transparent soaps of various degrees of transparency could be made from cocoanut, castor, corn, cottonseed, linseed, peach kernel, menhaden fish oil and rosin. The formulae were worked out so that the per cent of water, alcohol and sugar was the same as is generally used in soap commonly made from tallow, cocoanut oil and castor oil. It was found that the melting points of the fats and the titer of the fatty acids when approximately the same for the various combinations gave soaps of equal value in transparency. This would indicate that the solubility of the soaps has much to do with reaching the point where satisfactory gels can be produced.

E. K. PLYLER—*The Quantum Theory and its Modern Developments.*

The origin of the quantum theory was discussed. The application of this theory to heat, electron phenomena and radiation and emission of light was briefly given.

Light quanta were explained and different experiments noted that upheld this theory of light. The wave theory of light was shown

to be in contradiction to the theory of light quanta. The final outcome of these two theories will depend on the existence of an ether. Einstein's Theory of Relativity tended to show that the ether does not exist. But recently Professor D. C. Miller has repeated the experiments of Michelson and finds that there is an ether drift. If his work is upheld, the wave theory will be sufficient and the light quanta will not take its place.

284TH MEETING, DECEMBER 8, 1925

MAJOR HAROLD C. FISKE, Corps of Engineers, U. S. Army—*The $500,000 Power-Navigation Survey of the Tennessee River and its Tributaries in Tennessee and North Carolina.* (Illustrated.)

285TH MEETING, JANUARY 12, 1926

ENGLISH BAGBY—*Psychological Effects of Low Oxygen Tension with Relation to Aviators.* (Published in First Bull. Medical Research Laboratory, Mineola, L. I., N. Y., 1919.)

H. F. JANDA—*Reinforcement in Concrete Pavements.* (Published under auspices of Highway Research Board, National Research Council, Part II, Proc. 5th Annual Meeting.)

286TH MEETING, FEBRUARY 9, 1926

OTTO STUHLMAN, JR.—*Developing Ultra-Violet Spectrum of Iron by Electron Bombardment.*

COLLIER COBB—*The Sand Dunes of Niigata.*

287TH MEETING, MARCH 8, 1926

J. F. DAUGHERTY—*Electrodeless Ring Discharge in Iodine Vapor.* (Illustrated.) (See abstract in Proc. N. C. Acad. Science.)

H. V. WILSON—*Studies on Sponge Cells at the Tortugas.*

288TH MEETING, APRIL 20, 1926

S. C. OGBURN—*Analytical Separation of the Platinum Metals.*

E. T. BROWNE—*Involutory Collineations Belonging to a Pencil.*

This paper is a continuation of the paper on "General Properties of Involutions in n-ary Algebra" which was presented to the Academy at the 1925 meeting.

An involution is a projective correspondence of period two. Any

matrix A, not itself a scalar, but whose square is a scalar, is the matrix of an involution. Every such matrix arises as the product of a constant (real or imaginary) by a matrix A which possesses the property

$$A^2 = I,$$

where I denotes the Unit Matrix, or the matrix of the Identical Transformation. If A and B are two matrices both of which possess the property that their squares are equal to the Identity, it is not in general true that

$$C = \frac{\lambda A + \mu B}{\lambda + \mu} \qquad (\lambda + \mu \neq 0)$$

also possesses this same property. If, however, A and B are such that C always does possess this property, we shall say that *A and B belong to a linear class.* In this paper a study is made of pairs of matrices A, B which belong to a linear class. The paper is primarily algebraic in its background, where the number of variables is n. For $n > 4$, the algebraic results have no proper geometric interpretation, although for $n = 3$, and $n = 4$ the general theory leads to very interesting results in the plane and in space.

In this paper necessary and sufficient conditions (both from an algebraic and from a geometric standpoint) are found that A and B may belong to a linear class. A scheme is given for finding the total number of linearly independent fixed points that the two involutions have in common, together with a scheme for finding the distribution of these points. A similar scheme is given for planes. Finally, a complete study is made of the fixed points of the typical involution C of the class and their distribution relative to the fixed points of A and B.

289TH MEETING, MAY 11, 1926

R. M. TRIMBLE—*Filter Sand Studies.*

W. F. PROUTY—*The Triassic of the Durham Basin.*

The Deep River Area is in two distinct basins. These basins have been named by the writer for the largest city occurring in each. The southern portion of the Deep River Area has therefore been called the Sanford Basin and the northern portion the Durham Basin.

The rocks of the Durham Basin differ from those of the Sanford Basin chiefly in their lack of the coal and black shale series, so well developed about Cumnock. In many respects the rocks of the two basins are

similar. They each have conglomerates along the western and eastern borders of the fields and each is made up of many types of sediments which are variable, lensey and poorly sorted.

The structure of the Durham Basin is also very similar to that of the basin to the south. The rocks for the most part have a monoclinal dip toward the southeast. This dip varies in most places from 5 to 30 degrees. In general the inclination is not far from 12 to 15 degrees but locally it is 45–50 and in some places there is a reversal of the usual southeast dip. Such areas of northwestwardly inclined rocks are probably associated with faults whose down throw side is on the west. On the east the Durham Basin is terminated by a great fault whose throw is probably not less than ten thousand feet. A part of this movement took place toward the end of Triassic time. The fractures caused by the earlier movements along this fault zone have been healed by precipitated quartz, so that there is to the east of the Triassic Basin in most places a well developed line of quartz ledges marking this zone of mineralization.

In many places along the eastern border of the basin occur conglomerates with immense boulders of gneiss, schist or granite. These are usually but little waterworn and give evidence in some places of having been accumulated in the greatest confusion, as through rock slide or rock streams. Some of these observed rock pieces were more than five feet in largest dimension. Conglomerates farther away from the eastern fault are smaller than those near it, which proves their accumulation from the east. At the present time these beds of conglomerates dip toward the east with an average inclination of from 5–15 degrees. These conglomerates must originally have had a westwardly dip of approximately 10 degrees, and they now extend 2 miles westward from the fault. From this it is concluded that tilting of the basin has taken place in part at least since the formation of the conglomerates on the eastern border, and the amount of the displacement causing the tilting can be estimated.

Beside the eastern boundary fault there are a number of minor faults in the basin running roughly parallel with the eastern side of the basin. There are also other faults cutting diagonally across the basin. These are best exhibited along the western edge of the field and are the most common causes for the offsets along the western border.

A study of the Durham Basin in relation to the other Triassic Basins in eastern United States has given rise to the formulation of a new explanation for their origin.

This explanation agrees with many authors in the general conception of an anticlinal axis passing to the east of the Virginia-Maryland-New York fields and to the west of the Connecticut and the Deep River fields. The new conception considers the area including all the eastern Triassic fields, with the exception of Nova Scotia fields, as belonging in the same great basin, whose eastern and western faults are of great throw. This great Triassic basin was block-faulted in a manner similar to the "Great Basin" of western United States, with differential throw in the different blocks. After erosion there remain here and there basins of Triassic materials. The Deep River Area including the Durham Basin, is on the east side of the block-faulted anticlinal basin, and the Virginia Triassic areas are on the west slope of this structure, but at different distances from the axis on this western slope. Each area occupies a position where the fault block basin, by deep faulting, has caught Triassic sediments and for the same reason has withstood the effects of erosion.

AN INVESTIGATION OF THE MICROPLANKTON OF CHESAPEAKE BAY[1]

By J. J. Wolfe and Bert Cunningham, with the assistance of N. F. Wilkerson and J. T. Barnes

Plate 1

The study of the Chesapeake microplankton samples was begun by the writer in the summer of 1916 under the supervision of Dr. J. J. Wolfe at Beaufort, N. C. During the following summer the work was carried on in the laboratories of Trinity College, Durham, N. C., in the same manner. Work was then suspended until the summer of 1921 when the responsibility for the work was left to the writer, due to the death of Dr. Wolfe. Messrs. Wilkerson and Barnes were added to the staff. The work was continued during the summer of 1922 with the assistance of Mr. Wilkerson alone.

Identifications of the diatoms were made by Dr. Wolfe and, although errors may have crept in during the counting, there is no doubt but that the species indicated as occurring are present in the Bay. However, in some cases, there may be some doubt as to the quantity. The identifications of protozoa were made by the writer.[2] The counting during the first two summers was done entirely by the writer, but later Mr. Wilkerson and Mr. Barnes assisted in this work. It will readily be understood that in the later work the personal element must enter somewhat, which may explain some apparent inconsistencies. Yet, even though the personal equation did not enter, one would find it difficult always to be consistent with the numerous small forms which resemble one another so closely. This is true not only of species, but also of genera. It is difficult indeed to differentiate at low magnification small forms of *Cyclotella* and *Melosira; Donkinia* and *Pleurosigma; Cocconeis, Raphoneis,* and *Navicula.*

[1] The work on this report was made possible by grants from the United States Bureau of Fisheries and Trinity College. The materials were all collected by the Bureau of Fisheries. The more complete report has been condensed and then finally abstracted. The abstract appears here.

[2] Mr. Cunningham.

This great similarity of different forms has led us to throw comparatively large numbers into the indeterminate group. However, there is a large number of genera and species which may be counted with considerable certainty and these have been carefully tabulated.

THE OBJECT OF A MICROPLANKTON INVESTIGATION

When one undertakes a tedious piece of scientific investigation the first question asked by his friends is—What is the use, what is the value, what is the practical application?

The value of a plankton investigation is at least two-fold: First, *purely scientific*. From this standpoint we are able (a) to determine what organisms exist in the area surveyed, and thus are led to find new species, or observe further occurrence of species which may be considered as rare; (b) to determine the conditions, both physical and chemical, under which the organisms may and do live, and the relation of these conditions to each species; (c) to determine the life cycles and the "pulse" cycles of each species and the possible cause or causes of the latter. Second, *applied scientific*. While but comparatively few of the fishes are wholly dependent upon the plankton directly for food, still it seems altogether probable that the great bulk of sea life is ultimately supported by the microscopic plants and possibly microscopic animals. There is undoubtedly considerable organized food emptied into the ocean from the rivers and their tributaries, but such a supply seems wholly insufficient for the maintenance of the great bulk of life by the oceans. This, in the end, must be maintained largely by diatoms, and other unicellular plants.

It seems quite possible that certain types of the plants would prove more satisfactory as food for certain fishes than others, and although that has not been studied in this paper, it should be thoroughly investigated, since the failure of fish to prosper in certain localities may be due to the lack of a proper "ultimate food," or, possibly a vitamine producer. Further, a plankton study may show not only the shortage of a certain species which may be vital for some larger form, but it may also show a depletion of all the planktonts, and the waters may then be compared to a "poor soil." Possibly the application of the "pure science" may reinvigorate the depleted waters and the crop may be considerably increased. Plankton analysis seems to be as imperative as soil analysis. Further, a plankton analysis may show an abundance of ultimate food, but there still remains the problem of the transformer, some agent which will carry over this food to the fish, such as Crustacea and other micro-organisms.

Having discovered the "ultimate foods" and their carriers, it would be well worth while to try to increase them and thus hasten the growth of desirable fishes. Possibly there are considerable differences in the foods of desirable and undesirable fish, and if so, a differential rate might be established.

Since there is probably a close relation between the photosynthetic rate and the reproductive rate in the diatom planktonts, a study should be made as to methods for increasing the photosynthetic processes. At present, based upon the data given herein, the two most important factors of photosynthesis are light and temperature.

These factors in nature are beyond control but in hatcheries where forced feeding might be practiced with advantage, this might be of considerable importance.

The cause of so-called fish epidemics such as have recently visited the Atlantic seaboard might be determined and remedies discovered by a careful survey of the water and a study of its plankton and fish relations. Furthermore, the variation of forms from the normal might be found to act as indicators of sewage pollution and the effects of industrial wastes as indicated by Forbes and Richardson (1913), Purdy (1916), and Moore (1922).

A comparison of the plankton of various bodies of water should aid in the determination of the advisability of transplanting fish and should give an immediate indication as to the probable outcome.

Literally, "the planktonts form the pastures of the sea upon which to graze the multitudes of its living things."

GENERAL METHODS

There are three principal methods for plankton collection; (1) the net method by which a given volume of water is strained and the volume and contents of the collected materials studied. There are fallacies in this method, as has been shown by Kofoid (1903), Ward (1899), Reighard (1898) and others, which are difficult to overcome and for which it is difficult to make proper allowances; (2) the plankton pump method, advocated by Kofoid (1908), in which a given volume of water is removed from a vertical column of the sea and is filtered, the residue being studied quantitatively and qualitatively; (3) the collection bottle method, in which a collection bottle is lowered to a definite depth where a messenger is sent down to close the bottle. A definite volume is drawn and the contents studied. In this investigation this latter method was used.

There are also three methods by which the plankton may be concentrated. (1) By filtration, (2) by precipitation in settling tubes by the action of gravity, and (3) by centrifuging. Ward (1899) has gone into some detail as to the relative merits of the two latter classes, ultimately deciding in favor of the centrifuge. This is the method which was used in this work.

In the qualitative study various methods have been used. Gran (1912) used a Sedgwick Rafter cell; others used a flat slide with higher magnifications. We began with a Sedgwick Rafter cell but could not secure the desired magnification, so hollow ground slides with square cover glasses were adopted.

METHODS OF COLLECTION AND PRESERVATION[3]

Surface collections were commonly made by rinsing a clean bottle with sea water, filling, and pouring the quantity to be preserved into a clean graduate previously rinsed with the surface water. This was then poured into the permanent container. Occasionally the water bottles mentioned below were used in making surface collections.

Below surface collections were made by means of bottles used for the collection of sea water for titration. Three types of bottles were used, viz., Ekman, Bigelow, and Bigelow and Green. They were handled in the same manner as in collection of samples for titration. When landed, 250 cc. of the water was withdrawn by means of the pet cock into a graduate and then poured into the container.

Samples were preserved in lead glass bottles, with patent porcelain stoppers with a rubber ring. The stoppers were held in place by a spring.

To the 250 cc. of the sea water collected in the above manner 12½ cc. of a modified solution of Flemings fluid were added. This was composed of one gram osmic acid, 7½ grams of chromic acid, 50 cc. of glacial acetic acid, made up to a liter with distilled water. Later collections were preserved in 4% formaldehyde, which proved about as satisfactory as the special killing fluid.

The material collected and preserved was then transported to the laboratories where the following methods were pursued.

CENTRIFUGING

The materials were centrifuged for concentration and also to determine the volume of the precipitate. This was carried on by means of

[3] This section was written from memorandum submitted by the Bureau.

an International Instrument Company's Centrifuge of type 1, driven by an electric motor. The machine was provided with two heads, one to carry two tubes of 150 cc. capacity each, and the other to carry four vaccine tubes of 10 cc. each. Squibb's separatory funnels with stop cocks were used in the former, while Hopkin's vaccine tubes were used for the latter. Special tubes of greater accuracy were ordered for use in the place of the Hopkin's tubes but they arrived too late to be of any service.

The contents of one of the containers was equally divided between two of the concentration tubes. These were placed in the carriers and rotated for eight minutes at a speed calculated to produce 1,500,000 dynes.[4] The dynage was calculated by the following formula.[5]

$$\text{Dynage} = SW^2\left(\frac{r^2 - r'^2}{2}\right)$$

S = density, W = angular velocity; r = distance from axis to bottom of fluid, r′ = distance from axis to top of fluid

Five cubic centimeters were now withdrawn from each of the tubes through the stop cock into a Hopkin's vaccine tube and treated as described below. In order to see if the precipitation were complete under the above circumstances the following test was applied. After the usual 5 cc. has been withdrawn from the concentration tubes, they

[4] The electric current at Beaufort was exceedingly variable and though under rheostat control, varied from 1000 to 1150 revolutions per minute. However, these variations are of small importance, as will be seen from the following table showing readings for 250 cc. of sea water from various stations at different dynages:

STATION NUMBER	1,428,960 DYNES VOLUME	1,745,230 DYNES VOLUME	2,150,960 DYNES VOLUME
8683-S	0.030	0.030	
8671-S	0.017		
8677-S	0.020	0.020	
8685-S	0.020	0.029*	

* Probably due to error in reading.

[5] In Kofoid's formula (See Bull. III. State Lab. Nat. Hist. **6**: 257) there is evidently a typographical error, since he gives

$$\text{Dynage} = SW\,\frac{r^2 - r^2}{2}$$

Using his figure we get approximately 13,000 dynes. If, however, we use W^2 in place of W we get his stated dynage.

were again centrifuged for thirty minutes at the same speed. Five cubic centimeters were again withdrawn from each and concentrated in a vaccine tube. The number of organisms occurring were counted in the manner given below. Station 8417-S treated in this manner gave a total count of 60 organisms in the 10 cc. thus secured, which really represented the precipitate from the remaining 240 cc. of sea water. Calculated, this gives us 250 organisms to the liter of sea water. The total number of organisms for this station as determined from the first 10 cc. withdrawn was 11,440. This gives an error of approximately 2%. Since there were some 530 bottles to concentrate, it was not thought worth while to increase the time to thirty minutes.

After four of the Hopkin's tubes had been filled to the 10 cc. mark with the concentrate as described above, they were placed in the centrifuge and rotated at a speed calculated to produce about 1,500,000 dynes. These tubes were also rotated for eight minutes. The volume was then read with the aid of a lens. Tests were made when the special tubes mentioned above arrived, and several bottles were recentrifuged. The original readings were found to be closely correct. Some errors crept in, due to the roughness of the glass at the top of the capillary tube and some of the material was not precipitated by this method and time. In order to determine the errors due to these causes 5 cc. were withdrawn from the surface of the Hopkin's tube from station 8417 after it had been centrifuged for the usual eight minutes, and this was centrifuged for thirty minutes more and the volume determined. This showed an error of 6%. This test was not made, however, until a considerable number of samples had been run, it being inferred that all the organisms precipitated in the concentration tubes in eight minutes at 1,500,000 dynes would also be precipitated in the Hopkin's tubes under these conditions; hence it was deemed inadvisable to change the time, but rather to keep the conditions as nearly alike as possible in this work.

After the reading had been made, the precipitate was thoroughly stirred by means of a long pipette and the contents poured into a bottle of about 12 cc. capacity. (It is to be noted that there was exactly 10 cc. of this substance.) These bottles were then sealed with paraffine.

COUNTING

From the small bottles mentioned above, 1 cc. of the concentrated sea water was withdrawn by a pipette. The water was thoroughly stirred before the removal of this one cubic centimeter and the pipette was drawn from the bottom to the top of the bottle as it was filling.

The pipette used was of the quantitative type. This one cubic centimeter of concentrated sea water was now placed in a Hopkin's tube and the tube filled with the filtered formaldehyde of about 4% concentration and the material centrifuged for eight minutes at 1,500,000 dynes. All the liquid above the capillary tube was then withdrawn and the precipitate in the capillary tube stirred by means of a long pipette, and (the drop or two) placed on a slide with a concave surface, about 16. mm. in diameter. Here it was allowed to settle for a while and if the volume of liquid were too great it was slowly evaporated until the cover glass would rest properly over the liquid. An effort was made to use a Sedwick-Rafter cell which held exactly one cubic centimeter, but we found that we could not use any objective higher than the $\frac{2}{3}$". Since this did not give us sufficient magnification for the determination of many of the species, the hollow ground slide, which is usable with a lens of 8 mm. focal length, was adopted.

The counting was done by means of an 8 mm. lens and a Bausch & Lomb No. 10 eyepiece. However, a No. 18 eyepiece was used frequently to determine a species. All forms visible with a No. 10 eyepiece were counted. If a species could not be determined because of the size or position it was called indeterminate. Among the diatoms these were divided into round and linear indeterminates.

In order to secure a definite area on the slide in which to count, a cover glass was etched with a square and placed in the eyepiece. This square gave an area of definite outline and the area could be easily controlled by the mechanical stage. The slide was so placed that one edge of the cover glass coincided with the edge of the square. Some object was then selected, and the eyepiece so adjusted that the object on the slide would travel in a line parallel to both sides of the square, when the slide was moved from right to left, and vice versa, by the mechanical stage. Beginning now at the corner of the cover glass, all objects in the square were counted and tabulated in the manner given below. The slide was then moved the width of the square and the count made as before. This was repeated until the opposite end of the cover glass was reached. The slide was then moved perpendicularly the width of the square, and back again square by square to the side from which it started. This was continued until all the area under the cover glass passed under the square. All the organisms on the slide were counted except in a few cases where the numbers ran into the thousands and then one-half of them were counted. When only half of the organisms were counted, usually alternate rows across the field

were taken, the average of these two being as the number in the row which lay between.

A sheet of paper was fastened to the desk and as the species occurred they were written down and checked. When an organism occurred more than once a straight mark was made for each occurrence. These were finally totaled and the results tabulated on cards.

In the beginning both the living and dead counts were made, but since we desired to find available fish food, it was thought best to discard the count of the empty shells of the diatoms and count only the living and recently dead diatoms. The presence of the chromatophore was taken as evidence of a living organism. Some forms, however, such as *Skeletonema*, *Chaetoceros*, and small forms of *Cyclotella* had chromatophores that were difficult to see, and all these were counted as living forms.

By chance it was found that some organisms which were not visible in the liquid mount were very distinctly seen when the mount was dried. Some of the earlier counts were not dry counted. Due to the excessive time required to make dry counts they were discontinued during the last two summers.

LOCALITIES OF COLLECTIONS

The materials examined in this work were collected by the U. S. Ship Fish Hawk in Chesapeake Bay. The selection of Chesapeake Bay for this survey was particularly fortunate since: (1) The bay is a source of considerable food fish, crabs and molluscs, and current rumor has it that these supplies are gradually being depleted and a question has been raised as to the cause. (2) The bay is the receptor of several large rivers which, in turn, are the recipients of sewage from several large cities and thus opportunity is given to study something of the effects of sewage. (3) The bay, being connected directly with the sea, must undergo considerable changes of salinity, pH, and influx of marine organisms. The effects of these great changes upon these organisms may be studied. (4) Perhaps most important of all, a hydrographic survey of the Bay was being made at the same time the collections were made. This survey gives most of the data needed for interpretation of the facts, many of which would be mystifying except for this information, but unfortunately, no data were secured as to photometry. This seems a very vital point to the writer, as we are of the opinion that light is a potent factor in the vertical distribution of diatoms.

The latitude and longitude of a place where a collection was taken

were registered, so the place was definitely located. This was called a station. If collections were made at more than one depth they were registered as 8339–9 meters, etc. Meters were used in part of the work and fathoms in the balance. However, all fathom readings have been reduced to meters in this work. The date of collection as well as other facts concerning the tides, temperature, the condition of the bottom, the winds, the condition of the sky, and the time of year were noted in the log book. In the later collections the direction of the current, salinity, and the pH concentration were added to the data. A series of collections were thus made covering a large part of the Bay.

After a period of from six weeks to three months collections were again made in these same localities, and as near the previous positions as practicable. This was continued from October 22, 1915, to September 12, 1916, as many as eight collections being taken from time to time in the same locality. This work was begun again on January 10, 1920, and continued until June 3, 1921, thus adding a number of collections to each of the above localities. These localities have been termed areas and designated as Area A, B, etc. An area thus includes all the collections made at a given locality. The areas and their locations are shown in the accompanying map (Plate 1).

A glance at the various areas will show that they are of a very diverse nature and that some of them are more desirable for study than others. Certain regions were selected for study. Those having the greatest depth were first chosen; then those most nearly representing the year's collection; then those giving the most general distribution over the Bay. It was the general policy to count the surface and bottom in all Areas. This was thought advisable after making several comparisons on surface and nine-meter counts of several stations, in which there was but little variation. Later investigation, however, showed considerable variation at these depths, but in the time allotted for this work it was impossible to make all the counts for all the stations at all depths.

DESCRIPTION OF AREAS

Although the areas, E, F, and G lie in a line across the mouth of the Bay between Cape Henry and Cape Charles, they present hydrographic differences.

Area G lies in a channel and has a greater depth than any of the other stations. It is connected to the open sea by a deep channel and there is practically no shoal water surrounding it; the twenty feet line lies comparatively close to the shore line within the Bay as well as on the ocean side.

Area F is in shallower water but still lies on the channel which, having passed the cape, divides, one branch going nearly due west toward Old Point and the other due north for a short distance, then to the north-west. Area F is located on the turn. Between this Area and the ocean there is a large area having a depth of 20 to 25 feet. To the west lies the Horseshoe and the Tail of the Horseshoe, both of which range below 20 feet in depth. To the north are the shallower middle grounds.

Area E lies still further north. While nearly surrounded by what one might call deep shoal water, it is in deep water on what appears to be another channel which has been cut in two a little further east by a sand bar, so that this area is not in connection with the open sea by a deep channel, although not more than a mile of sand separates the two channels. On the south and west in the "middle ground" with 12 to 18 feet of water; to the north-west is the Inner Middle Ground with its point of nine feet shoal. North is Fisherman Island with its shoal water, and east is Nautilus Shoal.

In like manner the Areas, A, B, C, and D lie in a nearly straight line across the Bay between the village of Cape Charles and New Point Comfort. Area A lies nearest Cape Charles. One might call it a deep hole since it is about 150 feet deep and is surrounded on all sides by shallower water. To the east the rise is very rapid, while to the south and west there is a large basin which is from 25 to 50 feet deep. This basin is connected to the river channel of Area F by a narrow channel of about 35 feet, and to Area E by the narrow Beach Channel which has an average depth of about 37 feet. The Middle and Inner Middle Shoals lie between Areas E and A. To the north of A there is a continuation of the deep channel.

Area B lies slightly north of west from Area A on the western edge of the basin described above and is in much shallower water.

Area C is separated from the Area B by a slight elevation of the bottom and is directly connected, by a slight depression of the floor of the Bay, with Area F. About 5 miles to the southwest lies the York Spit, and to the west, the Mobjack Bay. Northwest are the shoals surrounding New Point Comfort, and to the north, the basin increases slightly in depth.

Area D lies in the shallower water just a little distance from the hook on the shoal east of New Point Comfort. The Wolf Trap Shoals lie directly to the north, while the point of York Spit is nearly directly to the south.

Areas H, H′, Q and O form another line across the Bay. Of these

areas H and Q are the most nearly alike. They are both connected with the B and C areas by a deep channel, and lie in an almost direct line with them. Area H is in immediate proximity to the point of Rappahannock Spit, although the area itself is in deep water. Area O lies to the north and west of shoal water.

Areas J, I, and K form another line across the Bay. Of these, I is most favorably situated to receive the current from above and below. J is located in a deep hole, but has shoal water immediately to the west surrounding Smith Point. Area K lies to the edge of shoal water, and to the northwest of Tangier Island.

Areas N′, N, and M lie across the mouth of the Potomac. Area M lies in the middle of the river and is in deep water. Area N′ lies behind Point Lookout and is in the vicinity of shoal water. Area N lies near shoal water on the opposite side.

Areas P, L, and L′ form a row across the Bay just above the mouth of the Potomac. L lies to one side of the deep channel, and P is just to the other side, but does not lie in the channel. P lies closer to shoal water and waters coming down the Bay might cross the shoals back of Point no Point light before reaching this area. Although area L′ is connected by a channel to areas I and K, there are considerable shoals to the east, south-east and south. On the incoming tide, this area should vary more widely from Area L than on the outgoing tide.

Areas R′ and R are set on opposite banks. R, however, is in the channel which here runs along the edge of shoal water. R′ is in shallow water but is farther from shoal water. R′ would probably be affected on the incoming tide by the water from the Patuxent River.

Areas S and T are also set on opposite sides of the Bay, the former in much deeper water. However, on outgoing tides, S would be much more affected by the flow from the Choptank River area than would Area T.

Areas V, W, and X form the next series. While W is in the middle of the Bay, it lies in much shallower water than X, which lies in the channel at the edge of the shoals just above Bloody Point Bar. Though in deeper water, X should show shallow water relations due to the shoals, and drainage from Eastern Bay on the flood tide. Area V is in close proximity to the shoal water on the west.

Areas Z and Y are also on opposite sides. These two areas are quite similar except that Z lies below the mouth of the dredged channel to Baltimore.

REGIONS

A glance at the accompanying map will show that these areas are arranged in groups forming lines across the Bay. They may, therefore, be conveniently grouped into regions. This has been done beginning at the lower end of the Bay. Region I includes Areas E, F, G; Region II, Areas A, B, C, D; Region III, Areas H, H′, Q, O; Region IV, Areas J, I, K; Region V, Areas P, L, L′; Region VI, Areas R, R′; Region VII, Areas S, T; Region VIII, Areas V, W, X; Region IX, Areas Z, Y; Region X, Area U; Region XI, Areas M, N, N′.

DISCUSSION OF THE DATA

It is somewhat unfortunate that all the data which have been collected and tabulated in this study of the plankton cannot be published, for they may be capable of interpretations other than those given by the writer. This mass of data, however, is so voluminous that its cost of publication is prohibitive. The original data, tables, etc., are to be filed with the Bureau of Fisheries where they may be found by those sufficiently interested.

It will be very difficult indeed to make any very definite statements concerning biological principles based upon these data. Unlike laboratory experiments where all the factors but one are held constant, and this one can be varied, and the results of the variations studied, nature never seems to do the same thing twice in this body of water. As an illustration, suppose it is desirable to determine the relation of a salinity to the total number of organisms. This could be easily done in the laboratory—but in the Bay—that is a far different matter. The surface salinity near the inlet may be identical with the salinity at a 30 meter depth up the Bay. This would mean that as a rule the light and temperature factors in such collections would vary also, even if the collections were taken at the same moment. If cloudy when the surface collection was taken, and clear when the 30 meter collection was taken, or vice versa, still other complications would arise. Or suppose again, that two collections were taken at the surface, at approximately the same time, under like conditions of temperature and sunshine, but of different salinities. These are then qualitatively studied and a considerable difference of total organisms may be due, not to the varying salinity, but to the pH values or the contaminations of one collection by toxic organic waters. Therefore, such conclusions as are reached here are only tentative.

STUDIES CONCERNING THE RELATION OF VOLUME TO TOTAL ORGANISMS

The first problem studied was the vertical distribution by volume of the plankton. If all the volumes are arranged according to depth and averaged there is a gradual increase in volume with depth. This is to be expected since, possibly, a considerable amount of the volume is due to the detritus which would naturally increase with the depth.

The average volume per liter of sea water for 253 surface samples counted was 0.049 cc., while that for the 208 bottom samples was 0.089 cc. The bottom samples ranged from 6 to 47 meters.

The vertical distribution of the total number of organisms per liter was next considered.

It became evident that the greatest concentration in some cases occurs at the surface, in others at 18 meters and still others at 27 meters. But, if, on the other hand, all the stations that have been counted are averaged, it will be seen that there is a large increase in the number of organisms occurring at the bottom over those occurring at the surface.

If cases were taken at any one station the steadily increasing numbers might not be evident. In fact, it is not unusual for the surface count to have more organisms than the lower strata. Nor is it an unusual thing for the counts to vary considerably at different depths. This is perhaps due in part to the manner of collection, but it may be due in part to the fact that the currents of water are not all moving in the same direction at the different depths. This will be more fully discussed when the 24-hour station 8800 is examined.

Since the volume increases with the depth as does also the total number of organisms it would seem that there should be some relation between the volume and the total number of organisms.

Generally speaking, the greater the volume the larger the number of organisms. This, however, does not hold true in specific cases, and one can not estimate the number of organisms to be expected in a collection by the volume of the collection, for there may be four hundred times as many organisms in the one collection as there are in another collection, although they have the same volumes of precipitate per liter. It would appear, therefore, that no specific relation between the volume and the total number of organisms is to be expected.

The practical value of a work of this type is dependent upon the collection of data based upon several years of collections, and the comparison of this data with data secured from other regions. Since the collections in this case were widely divergent and taken under consider-

able variations of physical and chemical conditions the data offers many opportunities for comparisons. These collections extended over a considerable period of time, thus permitting comparisons of annual pulses; they were taken at varying depths, under varying density, salinity, and various degrees of sewage contamination; they were taken in channels of considerable depth and in shallows. In these studies it was found that there were great variations as to total organisms, in one area, depth, and region as compared with another taken at approximately the same time. These variations will be discussed in the following pages.

VARIATIONS OF TOTAL ORGANISMS

(a) Various stations taken on the same day showed great variation in the total number of organisms even when the collections were made only a few hours apart.

(b) It has already been pointed out under the discussion of volume of precipitated material that there is a variation in the vertical distribution of the total organisms. A discussion of the probable causes will be given later.

(c) By tabulating the average total organisms of the various Areas one gets some interesting results. These are given on page 39.

These data are not altogether reliable since the same number of collections were not taken in each Area, and it is possible that some Areas showing small numbers of total organisms did not get collections at the time of the crests. Areas, however, having the larger numbers of collections are more comparable and probably form a reasonable basis for a study of causes.

(d) Other interesting results are found when the data are tabulated by Regions. There is less chance for error here than in the Area tabulation, since the number of collections in the various regions are more nearly the same.

It will be seen that two Regions, viz., No. II and No. VII, stand out predominantly above the other regions. The real value of these data, however, is dependent upon the distribution of the various collections throughout the year.

(e) There is also a diurnal variation. Area U was selected for a study of the collections taken during twenty-four hours. This area is at the head of the Bay and in comparatively shallow water. The collections were made in July when the pulse for the total number of organisms was near a minimum. With the exception of the 5 meter depth

this series of collections follows the general rule of vertical distribution as shown on page 40.

DISTRIBUTION OF ORGANISMS BY AREAS BASED UPON SURFACE AND BOTTOM COUNTS

Organisms per liter

	COLLECTIONS COUNTED	DIATOMS	PROTOZOA	TOTAL ORGANISMS
Area A	32	80,751	5,969	86,748
Area B	8	138,020	4,210	142,710
Area C	7	137,845	5,450	155,560
Area D	15	305,513	11,552	319,000
Area E	6	40,587	4,180	45,060
Area F	24	43,457	4,700	48,872
Area G	18	41,556	4,063	46,200
Area H	30	73,174	7,649	85,237
Area H′	7	45,700	7,270	53,286
Area I	25	74,334	19,127	88,857
Area J	32	91,878	7,233	98,018
Area K	10	27,897	4,868	40,164
Area L	21	126,985	7,200	136,587
Area L′	7	44,726	3,543	48,886
Area M	27	32,515	5,280	39,600
Area N	5	79,876	2,500	83,612
Area N′	9	96,715	9,640	106,842
Area O	6	21,080	3,945	25,507
Area P	25	77,873	3,945	83,200
Area Q	6	10,750	6,016	16,490
Area R	23	52,300	4,017	60,509
Area R′	6	136,560	5,715	143,405
Area S	6	168,480	6,867	175,977
Area T	14	74,200	4,785	80,000
Area U	12	12,913	7,090	20,777
Area V	6	13,807	6,600	20,020
Area W	5	112,936	1,920	117,520
Area X	25	41,788	3,638	49,418
Area Y	24	44,800	15,327	63,695
Area Z	25	19,081	9,444	31,674
24-Hour, Station 8800, Area U				
	59	23,124	9,521	37,021

It seems desirable that further examination of 24-hour stations be made.

(f) Though there is considerable variation of total number of organ-

DISTRIBUTION OF ORGANISMS BY REGIONS

Average organisms per liter

	CASES	DIATOMS	PROTOZOA	TOTAL ORGANISMS
Region I	48	42,384	4,393	47,390
Region II	62	148,964	5,734	158,000
Region III	49	55,224	7,000	65,080
Region IV	67	77,289	11,318	85,954
Region V	53	92,954	5,181	99,821
Region VI	33	69,773	4,365	75,540
Region VII	20	102,980	5,410	108,598
Region VIII	34	49,782	3,639	60,000
Region IX	49	31,675	12,013	47,358
Region X	12	12,913	7,090	20,777
Region XI	41	52,384	5,905	59,728

STATION 8800

Distribution of organisms according to depth. Average numbers of organisms per liter of sea water

DEPTH	NUMBER OF COLLECTIONS	TOTAL ORGANISMS	DIATOMS	PROTOZOA
S	15	22,532	6,592	10,970
5 meters	13	37,983	20,815	10,548
10 meters	15	26,637	16,236	7,574
12.5 meters	15	29,332	19,780	8,725

Variation of total number of organisms during a 24-hour period. Average number of organisms per liter of sea water. (Average of all depths taken)

TIME	TOTAL ORGANISMS	DIATOMS	PROTOZOA
2:30 p.m. (1)	46,280	19,480	13,960
3:55 p.m. (2)	31,013	15,490	14,786
5:20 p.m. (3)	47,090	18,990	15,220
6:58 p.m. (4)	40,450	23,470	13,280
8:28 p.m. (5)	21,750	7,520	8,040
9:58 p.m. (6)	25,185	11,940	10,470
11:28 p.m. (7)	40,250	26,870	11,490
12:58 a.m. (8)	19,415	11,460	5,120
2:28 a.m. (9)	15,920	10,630	4,140
3:58 a.m. (10)	13,954	6,073	6,293
5:28 a.m. (11)	17,391	11,165	4,420
6:58 a.m. (12)	28,080	11,496	11,013
8:28 a.m. (13)	34,591	21,651	9,910
9:58 a.m. (14)	25,990	14,890	8,140
11:28 a.m. (15)	30,860	23,760	5,840
12:58 p.m. (16)	31,770	18,220	10,230

isms by depths, Areas, and Regions, there is a much greater variation in any one Area or Station during the year. These variations are such as to produce two crests per year regardless of which Area is taken, provided the collections are taken throughout the year. One crest is in the late spring and the other in the fall. This annual crest of the total number of organisms is usually produced by the rapid development of one or two species, and a slight development of one of the other species. In most cases the dominating species is easily differentiated.

For this reason some of the more easily differentiated species which occur more or less abundantly have been studied.

Study of such a distinctive form as *Skeletonema* shows that it varies in occurrence in different regions and areas, and at different depths, and in the various seasons. While there are two forms of *Skeletonema costatum* present, one large and the other small, there is no chance of confusing this form with any other; hence any data secured are reliable. A form like *Actinoptichus undulatus* is more readily confused, especially the minute specimens, and although the data have been tabulated concerning this species, it is not nearly so reliable as that of *Skeletonema*.

Among the protozoa the most commonly occurring one is *Prorocentrum micans*, of which there are two forms, one consistently larger than the other. These may be two species, but all have been included under the head of *Prorocentrum*. No other form in the plankton except *Exuviaella* resembles this organism, and there is, therefore, no difficulty in securing the data. For similar reasons there is no opportunity to confuse the dinoflagellate *Ceratium furca*, so it has been tabulated, although at no time does it form any considerable part of the plankton. *Ceratium fusus* has also been tabulated. This form is also free from confusion with any other form, but like *Ceratium furca* forms only a small part of the plankton. Among the peridinials no effort has been made to further differentiate the genera or species. It is quite probable that an effort will be made toward a quantitative study of these forms, but that would require too much time to include it in this project.

Since the great annual variations are largely dependent upon the variation of some single organism, as shown in the original tables, it follows that a study of such organisms or other similar organisms may throw light upon the causes of these variations.

AN EXAMINATION OF SOME OF THE PROBABLE CAUSES OF VARIATION

There are two or three possible causes of the annual cycle which stand out prominently. Perhaps the most important one is rapid re-

production under optimum conditions. Here, due to some physical or chemical environment, a new stimulus is given, and the plankton population is increased many fold. Then conditions change and there is a rapid decline until a lower level is reached, to be followed in due time by another crest.

(a) The annual crests, one occurring in the spring and the other in the fall, indicate that temperature may be a factor in the reproduction rate of planktonts.

AVERAGE NUMBER OF ORGANISMS PER LITER OF SEA WATER AT VARIOUS TEMPERATURES

TEMPERATURE	CASES	DIATOMS	PROTOZOA
Below 36°F.	67	24,025	7,700
36–45°F.	82	56,681	4,868
46–50°F.	44	143,940	4,291
51–55°F.	20	140,323	4,854
56–65°F.	39	121,884	7,644
66–75°F.	123	20,364	7,283
76°F.	81	15,126	6,584

The tabulation shows that the optimum temperature ranges from 46–55°, and since there are two seasons in the year when the temperature of the water in the Bay must pass through these temperatures, the annual crests may be looked for at this time. Just when the waters will reach these temperatures, and how long they will remain within these bounds will depend upon climatic, tidal, and other conditions. It has been stated that the crests are due, as a rule, to the rapid growth of a single species, and it might also be said, generally, to a diatom species. Examination of the above table shows that the protozoa have a considerably different optimum than the diatoms; in fact the diatom optimum represents the protozoan minimum. The two crests for protozoa may be produced by two different species. This is not a necessary conclusion, however, since the data of *Skeletonema* shows that it may form a considerable part of the plankton at widely different temperatures. This further indicates the necessity of studying each form separately if definite conclusions are to be obtained.

(b) Another factor which is quite variable in the Bay, and which may be studied in conjunction with the varying plankton is salinity. Salinity in general may be changed by tides bringing in more sea water, and by the river drainage reducing salinity. In the latter case there might be two considerable changes per year, due to the spring and fall rains.

but it is doubtful if this would be sufficient to change the concentration to any considerable degree. That there is some relation of total number of organisms present to salinity is made evident in the following table.

DISTRIBUTION ACCORDING TO SALINITY

SALINITY	CASES	TOTAL ORGANISMS	DIATOMS	PROTOZOA
5.93– 8.00	17	25,480	9,968	10,272
8.10–10.00	12	37,300	19,878	12,036
10.10–12.00	12	25,621	13,268	9,258
12.00–13.52	16	28,081	20,736	6,498

Here again it is evident that the optima for diatoms and protozoa are different. Since most of the "Total Organisms" are diatoms, and since they appear to occur more abundantly in water of greater salinity than do the protozoa, and since the fall and spring crests occur about the time of the seasonal rains, it could not be logically interpreted that change in salinity due to river drainage could have a beneficial effect upon diatom growth.

There is one factor here, however, which should not be too casually cast aside; i.e., if diatoms require a substratum of organic material for rapid growth, it may be that the material brought down by the streams gives the proper basis for rapid growth and reproduction and hence the crests. The present data provide no evidence at all for this suggestion.

In conclusion then it would seem that the annual crests of plankton in the fall and spring are largely due to the water reaching an optimum temperature for rapid reproduction of the diatoms. This temperature need not be reached at the same time in succeeding years, or even in a given year in different areas, so the time of the crest can only be approximately ascertained and predicted. The time may also be varied by the "species" which form the major part of the plankton, since different diatoms may have different optima which can be discovered only by a study of each species in relation to temperature. This should be done, but can not within the limits of this work.

CAUSES OF REGIONAL VARIATION

As has already been shown, the various regions of this Bay show considerable variation as to the total organisms occurring and also as to the species. Regions II and VII are the most prolific as to the average number of organisms of all collections counted. Since these regions must have considerably different environmental conditions it would be

necessary to study the specific organisms occurring in each region and their annual pulse in order to determine the cause of the difference. It is hoped that this may be done later with the data in hand.

(a) In a general way one may say that the salinity of the Bay would increase from its head to the inlet. Taking the regions one finds in general an increase in diatoms with an increase in salinity, and an increase in protozoa with a decrease in salinity. With the cases in which data were secured as to salinity we find the following distribution:

DISTRIBUTION ACCORDING TO SALINITY

SALINITY	CASES	TOTAL ORGANISMS	DIATOMS	PROTOZOA
5.93– 8.00	17	25,480	9,968	10,272
8.10–10.00	12	37,300	19,878	12,036
10.10–12.00	12	25,621	12,268	9,258
12.10–13.52	16	28,081	20,736	6,498

Or arranged in ratios of protozoa to diatoms, using all salinities recorded:

APPROXIMATE RATIOS OF PROTOZOA TO DIATOMS AT DIFFERENT SALINITIES

SALINITY	CASES	RATIOS
0-10	25	1:22
10.1–15	80	1:11
15.1–20	104	1:18
20.1–	63	1:10

The cause of the irregular curve is not evident, but as suggested before, may be due to different types of protozoa.

(b) In so far as tides produce changes of salinity they might be considered in the above paragraph. But plankton is more or less inactive and becomes the sport of wind and wave, therefore many individuals must be carried in through the inlet on the floodtide and carried out on the ebb tide. If the plankton of the sea is rich it would seem that the waters of the inlet should show higher counts than those of the Bay. But such is not the case, the average here being lower than all other regions except the upper part of the Bay. It would be interesting to take collections outside the inlet and compare them in quantity and quality with the collections already taken. As a general rule the tides may be responsible for moving the organisms some considerable distance. To determine the effect of tides simultaneous collections should be made in different regions and at different stages of the tides.

The nearest approach to evidence that we have is a series of collections taken on the same day. The total organisms, time of collection, and the tides of these are given below.

		ORGANISMS		
Area G	8499	136,480	8:00 a.m.*	Flood tide
Area F	8500	443,140	8:30	Flood tide
Area A	8503	565,160	1:00 p.m.	Flood tide

* Time estimated.

Now, these are great variations and are all taken at flood tide. What is the explanation? The collection of the material of 8499, the time of which was not given, based upon collections taken at these places at other times, must have been about 8:00 a.m. Our time of collection, therefore, covers a period of five hours, and since the tide runs for about six hours we are justified in assuming that the first collection was taken soon after the tide had turned and the last, just before high tide.

If the tide had just turned from low when 8499 was collected, we should expect to find only such organisms and in such quantity as they appear naturally in the Bay, and this is probably the least number. The tide was considerably more under way when the collection was taken at 8500, which lies close to 8499 in the mouth of the Bay. Here we expect to find a greater number of organisms, and such is the case. Now, when the collection was taken at 8503, the tide will have nearly reached its height even as far up the Bay as Area A, and we should expect to find the greatest number of organisms. This is the case. However the data are insufficient to justify the conclusion that the tides are wholly responsible for the variation. This problem could possibly be best attacked by taking collections at a station at low tide, various stages of flood tide, at high tide, and the various stages of ebb tide. If this were taken into account with collections made up the Bay far enough to avoid organisms from the sea and collections made at high tide just outside the Bay, very definite conclusions could be drawn as to the influence of the pelagic forms on the life of the Bay and therein may lie the answer to the reported shortage of native fish life in the Bay.

(c) Some of the organisms found in the Bay are typical of certain regions fed by certain rivers. Among these forms found was a very rare *Tintinnus*. Search of the literature revealed no form figured like it. It was found in the areas near the mouth of the Potomac, and very

unexpectedly, while working over a copy of Hygienic Laboratory Bulletin (Purdy, 1916), for data on sewage pollution, the following statement was discovered:

"This organism evidently belongs to the genus *Tintinnus;* the lorica is cylindrical and is constricted near one end, producing a shape similar to that of a long bottle." This is an excellent description of this form. Evidently that author had also failed to find any name for this organism. We have roughly figured and described it in the Journal of the Elisha Mitchell Scientific Society, Vol. 38, September, 1922, but no name has been given to it.

(d) The proximity of shallow water may have some influence but from our data it would seem to be rather small. Examination of the location of station numbers 8499 Area G, 8500 F, and 8503 A, show that the first and last are near shallow water and that the other is in the middle of the channel. Further, it shows that the water passing near stations 8499 and 8500, in flowing out to sea, passes over some of this shallow area. Now the total number of organisms of 8503 which is in the channel is greater than those of 8500 and 8499 which lie closer to shallow water. There is a similar variation in 8349 P, 8350 Isolated, and 8353 R.

Since a region is really a cross-section of the Bay, its composite total would not be expected to vary as much from the composite total of other regions as one Area would vary from another in the same Region.

Other factors which might affect the total number of organisms in a collection are: relative depth to the bottom, the type of bottom, the turbidity of the water, and varying water currents.

ANNUAL VARIATION WITHIN THE AREA

It has already been pointed out that there are two crests per year in most of the Areas. It has also been indicated that each variation is due in a large measure to the rapid development of a single species. It was desirable, therefore, to find whether or not the two crests in a given Area were produced by the same organisms. Taking Areas at random, the data on page 47 was secured.

In the cases taken at random the fall crest is always caused by a different organism than that causing the spring crest.

RELATION OF THE PRINCIPAL SPECIES TO THE TOTAL NUMBER OF ORGANISMS

Surface counts (per liter)

AREA	PRINCIPAL SPECIES	NUMBER	TOTAL ORGANISMS	PER CENT
	Spring Crest			
A	Ceratulina bergonii	407,160	565,160	72.4
D	Skeletonema costatum	188,640	234,560	80
F	Rhizosolenia fragillissima	407,280	443,140	91.9
G	Rhizosolenia stolterfothii	126,000	136,480	92.9
J	Ceratulina bergonii	65,400	72,880	89.7
L	Ceratulina bergonii	40,360	57,520	70.1
P	Rhizosolenia stolterfothii	49,880	61,320	81.2
R	Chaetoceros	729,600	876,880	83
X	Rhizosolenia stolterfothii	595,840	632,860	94
X	(Crest in June) Prorocentrum	92,800	96,360	96.2
Y	Skeletonema costatum	309,000	368,000	83
	Fall Crest			
A	Rhizosolenia stolterfothii	79,040	97,760	80
D	Peridinials	24,000	76,560	35
F	Rhizosolenia stolterfothii	35,880	70,060	51
G	Collection not taken at time to show crest			
J	Ceratium furca	23,340	37,400	62.7
L	Collection not taken at time to show crest			
M	No one form			
P	Skeletonema costatum	24,480	34,520	70.8
R	Skeletonema costatum	25,840	63,720	40.7
X	Collection not taken at time to show crest			
Y	Prorocentrum	288,000	310,640	90
Z	Prorocentrum (June)	88,000	116,000	76

The relation of the organism responsible for the fall crest to that of the spring crest follows:

AREA	SPRING	FALL
A	Ceratulina bergonii	Rhizosolenia stolterfothii
D	Skeletonema costatum	Peridinium
F	Rhizosolenia fragillissima	Rhizosolenia stolterfothii
G	Rhizosolenia stolterfothii	Not shown
J	Ceratulina bergonii	Ceratium furca
L	Ceratulina bergonii	Not shown
M	Not shown	No one form
P	Rhizosolenia stolterfothii	Skeletonema costatum
R	Chaetoceros	Skeletonema costatum
X	Rhizosolenia stolterfothii	Not shown
Y	Skeletonema costatum	Prorocentrum
Z		Prorocentrum

MICROSCOPIC ORGANISMS OCCURRING IN CHESAPEAKE BAY

While the following list is not suggested as a complete or even approximately complete list of the species occurring in the Bay, it is set forth as a list of organisms actually occurring there. The diatoms were all identified by Dr. J. J. Wolfe, and the protozoa by the writer. Attention is again called to the difficulty of identification at lower powers in counting and the possibility of quantitative error; but species determination was usually made under oil immersion in the cases of diatoms, and at high magnifications, where necessary in the protozoa.

DIATOMS

Actinocyclus alienus Grun.
Actinoptichus splendens (Shadb.) Ralfs.
undulatus (Bail.) Ralfs.
Anaulus scarlaris Ehr.
Amphora Ehr.*
Asterionella formosa Hass.
Auliscus radiatus Bail.
Bacillaria paradoxa Gmelin.
Bacteriastrum varians Laud.
Bellerochea malleus (Bright) v. H.
Biddulphia aurita (Lyngb.) Breb.
granulata Roper
mobiliensis (Bail.) Grun.
rhombus (Ehr.) W. Sm.
smithii (Ralfs.) v. H.
Campylodiscus echeneis Ehr.
Ceratulina bergonii Perag.
Chaetoceros curvisetum Cleve.
decipiens Cleve.
Peruvianis Bright.
ralfsii Cleve.
teres Cleve.
Cocconeis*
Corethron hystrix Hensen
Coscinodiscus centralis Ehr.
concinnus W. Sm.
decoratus Brun.
excentricus Ehr.
lineatus Ehr.
marginatus Ehr.
occulis iridis Ehr.
radiatus Ehr.
senarius A. Schm.
Cyclotella*
Denticula*
Ditylium brightwellii (West) Grun.
Donkinia recta (Donk.) Grun.

Eucampia zodiacus Ehr.
Eunotia*
Grammatophora*
Gomphonema*
Guinardia flacida (Castrac) Perg.
Hemiaulis hauckii (Grun.)
Hyalodiscus stelliger Bail.
Lauderia*
Leptocylindrus danicus Cleve.
Lithodesmium undulatum Ehr.
Mastoglia*
Melosira sulcata (Ehr.) Kutz.
Navicula arenaria
bombus (Ehr.) Kutz
borealis (Ehr.) Kutz
brevis Greg.
cancellata Donk.
humerosa Breb.
smithii Breb.
Nitzschia plana W. Sm.
longissima (Breb.) Ralfs.
sigma (Kutz) W. Sm.
Plagiogramma*
Plagiotropis elegans (W. Sm.) Grun.
Planktoniella sol (Brightw.) Schuett
Pleurosigma affine Grun.
balticum W. Sm.
fasciola (Ehr.) W. Sm.
Raphoneis amphiceros Ehr.
Rhizosolenia alata Brightw.
calcar avis Schultze.
fragillissima Bergon.
imbricata Brightw.
obtusa Hensen
semispina Hensen
setigera Brightw.
stolterfothii Perag.
stricta Karst.
styliformis Brightw.
Skeletonema costatum (Grev.) Cleve.
Streptotheca thamesis Shrubs.
Stephanopyxis turgida (Grev.) Ralfs.
Synedra*
Thallassiothrix frauenfeldii Grun.
nitzschioides Grun.
Triceratium*

* Either forms of this genus occur so rarely, or their identification at the magnification used is so difficult that their separation into species was deemed either impracticable or not worth while.

PROTOZOA

Dictyocha fibula—Ehr.
Dictyocha pons
Distephanus rotundus
speculum—Baeck.
Ceratium furca—Ehr.
Ceratium fusus—Ehr.
Ceratium macroceros (Ehr.) Cleve.
Dinophysis acuta Ehr.
Dinophysis rotunda—Clap & Lach.
Dinophysis homoculus—Stein.
Peridinidae (Bergh)
Prorocentrum micans—Ehr.
Acanthrometra J. Mull.
Acanthosphera
Amphorella—Daday
Amphorella fistula Duc. Orleans.
Amphorella sublata Daday
Aulacantha—Haeck.
Chitonosperma—Duc. Orleans.
Conocylis helix Duc. Orleans.
Cornutella
Cyclotrichium cyclokaryon Duc. Orleans.
Cyttarocylis gigantea—(Brandt ?) Duc. Orleans.
Cyttarocylis hemifusus Duc. Orleans.
Dictyophimus tripus
Difflugia—Lecl.
Euplotes—Ehr.
Halosphera—Schm.
Lionotus—Wrzeniowski
Mesodinium cinctum—Calkins.
Noctiluca milarius—Suriray (Doflein)
Panduroform—Nitz
Polykrikos
Ptychocylis—Brandt.
Pyrophacus horologium—Stein
Pyrophacus noctiluca
Spheropsis—Duc Orleans
Spheropsis spumosa—Duc Orleans
Spongioxiphis—Haekel
Tintinopsis—Stein
acuta Duc Orleans
beroidea (Stein ?)
Davidoffi—Daday
fusus Duc Orleans

incurvata Duc Orleans
lata Duc Orleans
macropos Duc Orleans
major Duc Orleans
urnula Duc Orleans
Tintinnus acuminatus—Schr.
rapa—Duc Orleans
serratus—Kofoid.
bottle form*
Tiarina—Bergh.
Vorticello (sp.) Ehr.
Globergina
Helioza
Formanifera
Radiolaria
Rhizopoda

A form which so far has not been identified, and which is designated as "Desmid form" in our records occurs abundantly in some of the collections. Samples of this form have been sent to several investigators, but no satisfactory reports have been received.

Special mention should be made concerning the occurrence of the copepods. While the surface tow frequently shows great quantities of these organisms they are extremely scarce, or totally absent in the counts. It was at one time thought that the failure to find these organisms in the collection was due to the fact that only 250 cc. of the contents of the collection bottle were used for examination, and these were withdrawn, before killing of the organisms, through a stop cock. We had observed that, in the laboratory, at least, copepods swim away from the current, and hence we believed that few were withdrawn in the 250 cc. sample taken through the pet cock. The entire contents of the collecting bottle were therefore killed, and centrifuged and examined for copepods. This method was but little if any more successful than the former. However, no tow was taken at the time these latter collections were taken, and the copepods may have been really missing in the waters at that time.

Although the work done has been of a quantitative nature, the data thus far secured give but little indication of the "food values" of these waters. This is evident for several reasons:

First: No evidence has been secured as to the forms which really

* Nothing similar to this form is figured by Haackmann (1903).

constitute the food of the native fish of the Bay. This can be secured only by a painstaking examination of the stomach contents of a large number of commercial fish. This, however, should be done and checked against the list of microörganisms.

Second: This method does not consider the "dissolved organic" substances which may or may not be utilized by the fish as ultimate food.

Third: It has not considered the relative value of diatoms, peridinials, infusoria and copepods as food. Johnston (1908) states that 1 copepod is equal to 150 Ceratia, or 1500 Chaetoceri. It is desirable that the food values of any water should be calculated in terms of some unit, say "copepod," rather than given in the uncertain terms of total organisms. Any effort to compare waters of different regions must be very unsatisfactory unless some unit is adopted. As a possible substitute, dry weight and ash of a given volume of the water might more nearly give the actual food value of the water.

Comparison with Some Other Waters

In spite of the inaccuracies of the method, it would be interesting to compare this body of water with others where somewhat similar investigation has been made.

Johnston (1908) in a discussion of the subject, reports that in Kiel Bay there are 6000 diatoms per cc., or 6,000,000 per liter at the maximum of production. Hensen (1875) found in the West Baltic a maximum of 475 per cubic centimeter or 475,000 per liter. Our collections lie between these two extremes, our largest collection being 3,161,540 per liter. The average total organisms for all collections, which were well distributed over a period of two years, was about 75,000 per liter. How this compares with other averages we are unable to say. Many writers, among them Johnston (1908), speak of the number under each square meter of surface, apparently not considering the variation of depth, thus making comparison impossible. Some definite system of calculation should be adopted, such as given by Gran (1912) where the organisms are reported in terms of individuals per liter. Lohman (1903), using cubic meters, reports for the Mediterranean just off of Syracuse 2,425,665 organisms per cubic meter. This sea is considered as a "plankton poor sea." This would give 2425 organisms per liter. It is rare for the count of Chesapeake Bay to go this low, and the yearly average is nearly thirty times this. Certainly then, this Bay need not be considered in any sense as "plankton poor."

If the Bay is not "plankton poor," it should then be scientifically determined whether or not it is "fish poor." Rumor and tales have it so — but is it really? This could and should be determined. In case the Bay is "fish poor," it is probably due to one or more of three causes.

(1) The proper plankton forms, to act as carriers of the diatoms, etc., to the fish may be absent. Their absence may be due to incompatible conditions in the water other than shortage of food.

(2) Industrial contaminations of the waters may react directly upon the fish, and they may leave.

(3) The catching rate may far exceed the reproductive rate. The reproductive rate may be affected by waste materials, drainage, etc. This can be verified, however, only by a careful examination of the spawning habits of the native fish.

The writer is inclined to believe that if the Bay is "fish poor" the last cause is most probably the real cause. Nature through thousands of years has sought to establish a balance between species. After its establishment man's interference may bring about disastrous results, since nature cannot readjust herself in a short period of time.

Then, if the Bay is really "fish poor" because it has been fished out, the remedy must be fish culture; i.e., the raising of small fish in hatcheries and restocking the Bay with native fish.

SUMMARY

1. The volume bears little or no direct relation to the total number of organisms present.

2. There is a gradual increase in volume as the depth increases. This is due in part to (a) detritus and in part to (b) an increased number of organisms.

3. There are two crests during the year. These appear to be caused by the occurrence of great numbers of one or two species in each case.

4. There seems to be a definite relation between temperature and the total number of organisms, the optimum being 46–55 degrees.

5. There also seems to be some relation of the total number of organisms to the salinity. More remotely, therefore, there must be some relation of the total number of organisms to the tides.

6. There is a great shortage of the copepods in the count, probably due to the technique of collection.

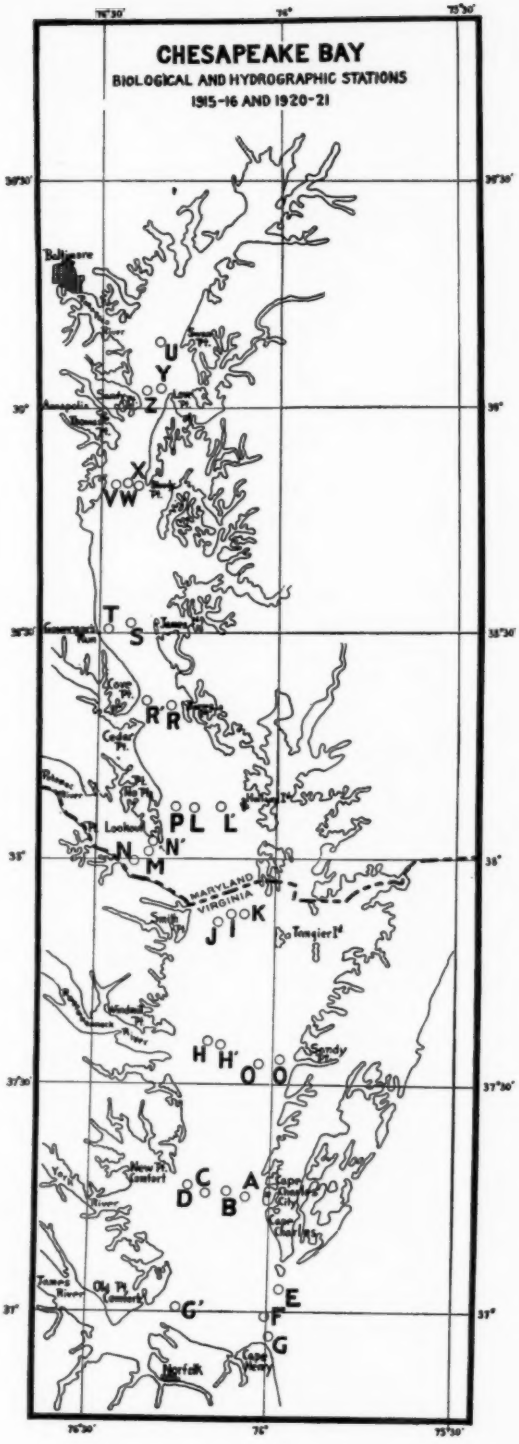
7. Neither the count nor the volume gives a true indication of the total food present. These two taken in conjunction with incineration and determination of ash would probably give a closer value.

8. Comparison of the Bay with other known bodies of water indicates that it is far from "plankton poor."

9. In this case, then, a "fish shortage" is due to either (a) a lack of "energy transformers," (b) wastes toxic to fish, or (c) an upset catch and hatch rate.

10. If the latter proves to be the case, the remedy lies in "hatcheries and restocking."

PLATE 1


CHESAPEAKE BAY
BIOLOGICAL AND HYDROGRAPHIC STATIONS
1915-16 AND 1920-21
76°30'
76°
75°30'
39°30'
39°
38°30'
38°
37°30'
37°
Baltimore
Annapolis
Cove Pt.
Smith Pt.
Point Lookout
Cape Henry
Cape Charles City
Norfolk
New Pt. Comfort
Sandy Hook
Tangier I.
MARYLAND
VIRGINIA
U
Y
Z
X
VW
T
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R
R'
P
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BROWN LEAFSPOT OF LEATHER LEAF FERN

By FREDERICK A. WOLF

PLATES 2 AND 3

Botanists regard ferns as objects of more than ordinary interest because of the fact that they exhibit such a well differentiated gametophyte or sexual and sporophyte or asexual generation which appear alternately in the life cycle. The interest of florists in these plants is essentially limited by their use as the source of "green stuff" in the preparation of wreathes, floral designs and decorations or in the composition of milady's bouquet and corsage. People generally regard the fern as an ornamental which is properly oriented only when it is growing in a flower pot or in some sheltered corner of the yard and do not consider it as a plant of economic importance. In Florida, however, it is to be regarded as a crop plant, since ferns are grown in plats varying in area from about a half acre to those which are sixty acres in extent. These ferneries consist of "slat houses" built to afford partial shade and in which there is installed either an overhead or an underground system of irrigation to provide an adequate supply of water. Several species of true ferns, including Boston ferns, *Nephrolepsis exaltata*, and leather leaf fern, *Polystichum adiantiforme*, and also *Asparagus plumosus*, commonly called asparagus fern, are grown in this type of fernery. Needless to say the ravages of insect pests and plant diseases constitute one of the problems which confront the fern grower, just as is the case with the one who cultivates any other crop. Among the diseases of the leather leaf fern is one which was first brought to the writer's attention by John R. Springer, Nursery Inspector, Orlando, Florida. This disease where is herein designated brown leafspot, was present in one fernery to such an extent that a large proportion of the fronds were unsalable. Since the disease does not appear to have been previously described an investigation was begun and the account of these studies to date is herein given.

SYMPTOMS

Diseased plants can be recognized by the presence of characteristic lesions upon the fronds. No evidences of disease have been noted upon the rhizomes and roots.

The first indication of brown spot is the presence of minute, circular specks on the pinnules. These enlarge within the period of a few days to become large, irregular lesions which are reddish brown above and ochre below. Spots which originate near each other fuse and may come to involve the entire pinnule. Quite commonly too the lesions extend along the margins of the pinnules and are limited by the veins (Plate 2).

No evidence of the fungus which causes these spots can be noticed except after a period of relatively high humidity or when affected fronds are kept in a moist chamber, after which the surface of the lesions is covered with a thin, grayish weft of conidiophores and conidia. If mature spots are examined with the aid of a hand lens the epidermis can be seen to be ruptured by the protrusion of minute, black sclerotia, which arise within the leaf tissues (fig. 5). These sclerotia appear to give rise to the fertile hyphae.

The rachis or stalk is also attacked as can be noted by the presence of sunken, elongated, brown lesions. Affected plants do not succumb to this disease but the fronds are rendered unsightly and in consequence must be discarded since they are unfit for market.

ETIOLOGY

The brown leafspot disease is caused by a hyphomycetous fungus belonging to the genus *Cylindrocladium*. This genus was first described in 1892 by Morgan (1), who reported *C. scoparium* as a saprophyte on the pods of honey locust, *Gleditsia triacanthos*. In 1900 Ellis and Everhart (2) described the same fungus as a new species of *Diplocladium* from specimens on dead leaves of papaw, *Asimina triloba*. This identity of the fungus on honey locust and on papaw was established by Massey (3), in 1917 in connection with his studies on a rose canker disease which he found to be caused by the same organism. This species remained the sole representative of the genus until 1918 when Anderson (4) reported that a second species which he described as *C. parvum* was frequently isolated as a saprophyte on the crowns of roses parasitized by *C. scoparium*.

The fertile hyphae of the fern *Cylindrocladium* are erect, hyaline, septate and for the most part dichotomously branched. One of the main branches quite commonly remains sterile, extends well above the fascicle of conidia and terminates in a clavate cell (fig. 6). The conidia are abstricted from the ends of the terminal branches and are held together in a mucilaginous matrix. When the conidiophores bearing conidia are viewed laterally they appear broomlike but as a matter of

fact the conidia are massed in a compact bundle with the ends at approximately the same level (fig. 7).

The conidiophores range in height from 175–275μ and are 6–7μ in diameter at the base. The club-shaped tip of the sterile portion varies from 8–10μ in diameter. The conidia are cylindrical, hyaline, 1–3-septate, bluntly rounded at the ends, and taper appreciably from the apex to the base. The average length, as determined by the measurement of fifty conidia, is 84.5μ, with a range of 64.6–98.5μ, and with a width of 5–6.4μ.

CULTURAL CHARACTERS

The conidia germinate promptly in culture with the formation at first of a single apical germ tube (fig. 3). The mycelium is at first whitish but within three to five days it becomes brown. An examination of the older hyphae at this time shows that they consist of bead-like chains of cells (fig. 4). The walls of these cells have become brown and are thickened. The cell contents are densely granular with several prominent oil globules. Within a few more days the pigmentation will have deepened to a reddish brown, very closely approximating the color of the leaf lesions, and the medium surrounding the colonies will also have become pigmented. The vegetative growth of colonies seven to ten days old on potato dextrose agar is rather closely adpressed to the medium but the fertile hyphae are erect and give to the surface the appearance of a filmy whitish coating. After two or three weeks small, dark brown sclerotia 100–180μ in diameter will have developed in abundance both at the surface of the medium and submerged in it.

ISOLATION

The fern leafspot fungus was isolated by planting bits of tissue from young lesions on agar plates. This method almost invariably yielded pure cultures of the parasite but in several cultures there appeared another *Cylindrocladium* approximately one-third as large as the form under consideration. This was at first thought to be a depauperate form and consequently search was made for transition forms but none were found. Both forms were isolated in monosporic cultures but remained constant even after repeated subculturing in parallel series.

The conidiophores of the smaller form (fig. 9) are 4–5μ thick at the base and the conidia (fig. 2) vary in length from 19–32.4μ by 3–3.5μ at the apex and 3.6–4μ at the base. They are hyaline, unicellular or

one-septate, and arise in the same manner as those of the larger form (fig. 9).

Aside from these differences in size of the fertile hyphae the two may readily be separated by the differences in appearance of the colonies on various media. These differences on potato dextrose agar are shown in plate 2, figure 2. The hyphae of the smaller form are more delicate but with a more copious production of aerial mycelium. The color of the colonies of the smaller form is less intense. Curiously too the small form is unable to infect leather leaf ferns under methods of inoculation which readily resulted in infections by the larger form. No adequate explanation can be offered at this time for this association together of a parasitic and a saprophytic species of the same genus. A similar situation has been described by Anderson (4) who noted that *Cylindrocladium parvum* is about one-third as large as *C. scoparium* and is associated with it as a saprophyte on decaying cankered rose stems. It may be suggested that the solution of the problem of this curious relationship might throw additional light on the subject of parasitism. That the fern *Cylindrocladium* and *C. scoparium* should each be frequently associated with a saprophytic form about one-third as large is certainly more than a peculiar coincidence.

PATHOGENICITY

Although pure cultures of a *Cylindrocladium* were almost always obtained from plantings of tissue of young lesions, which indicates that the leafspots are undoubtedly caused by this organism, nevertheless the fungus was used in inoculation tests. Plants bearing young fronds were inoculated with conidia from pure cultures. The plants were first sprinkled, after which the inoculum was applied by placing conidia in the drops of water adhering to the plants. The plants were then covered to prevent the removal of the inoculum by rains.

Infection occurs, as may be noted after 16 hours, by direct penetration of the infection hypha (fig. 8). Small necrotic areas are evident after 48 hours in all inoculated parts. Within a week the dead tissues will have become characteristically reddish brown and entirely similar in appearance to the lesions which arise on plants in the fernery. *Cylindrocladium* was successfully reisolated from young lesions on artificially inoculated plants so that it has been possible to comply with all of the requirements in the rules of proof of pathogenicity. When these lesions become old they are invaded by *Colletotrichum* sp. which makes it difficult or impossible to isolate the parasite. It has been isolated, however, from lesions approximately eight months old.

Dryopteris normalis,[1] a common roadside fern, is subject to a leafspot which is similar in appearance to brown leafspot of leather leaf fern. Old lesions only have been available for isolations and these have yielded *Colletotrichum* sp. so that isolation trials have failed to prove them to be identical. However, in inoculation tests with the fern *Cylindrocladium* made in the same manner as with leather leaf fern, infections were readily secured and the resultant lesions were like those naturally present on this species of *Dryopteris*. This fact together with the observation that the Boston fern is also subject to infection leaves little doubt that the fern *Cylindrocladium* probably attacks a number of species of ferns and is indigenous to Florida.

IDENTITY

Cultures of the fungus under consideration were sent to Dr. L. M. Massey, Cornell University, Ithaca, N. Y., for comparison with *C. scoparium* on roses. His measurements of the conidia of the fern fungus show that the average length is 87.8μ with a range of 67.5–112.5μ which accord closely with the writer's measurements as previously given. His measurements (3) of conidial sizes of *C. scoparium*, however, show that it is approximately half as large since this species is 36–55 by 3.3–4.5μ with an average of 48.3 by 4.13μ. As every mycologist knows conidia vary in size depending upon the conditions under which they are produced, but this variation would never be sufficiently great to account for the differences in size given above for the fern fungus and the rose canker organism. On a morphological basis therefore, they must be regarded as specifically distinct and so the name *C. pteridis* is proposed for the fern parasite.

The following is a brief technical summary of the descriptive features:

Cylindrocladium pteridis n. sp.

Lesions minute, circular at first, later becoming large irregular areas, reddish brown above, ochre below, conidiophores erect, base simple, dichotomously branched, apex of sterile branch clavate, 175–275 by 6–7μ; conidia cylindrical, unicellular to 3-septate, hyaline, tapering toward the apex, 64.6–98.5 by 5–6.4μ, average length 84.5μ. Parasitic on the fronds of *Polystichum adiantiforme*, *Dryopteris normalis* and *Nephrolepsis exaltata* in Florida.

Type material has been deposited in the Herbarium of the Office

[1] Thanks are due Dr. John K. Small, New York Botanical Gardens, New York, N. Y., for the identification of this species.

of Pathological Collections, Bureau of Plant Industry, Washington, D. C., and in the Herbarium of the University of North Carolina, Chapel Hill, N. C.

It is not deemed advisable until more can be known about the saprophytic form, which commonly accompanies *C. pteridis* to describe it as a distinct species.

CONTROL

Since both Bordeaux mixture and lime sulphur solution, the common fungicides, leave, on drying, a deposit which persists for a long time on leather leaf fern they are entirely unsuited for use in protecting against infection. This objection could of course be obviated by the use of certain other fungicides but it was felt that the removal and destruction of all diseased fronds offered the only practical means of control. Accordingly all affected fronds were cut off and destroyed in one small fernery. The results indicate that the application of eradicatory measures can be depended upon to control brown leafspot.

SUMMARY

This investigation is concerned with a leafspot disease of leather leaf fern which is characterized by the presence of reddish brown lesions on the fronds.

The disease is caused by a species of *Cylindrocladium* which is herein described as *C. pteridis*.

Artificial inoculations with pure cultures of *C. pteridis* have resulted in infections on leather leaf ferns and also on *Dryopteris normalis* and *Nephrolepsis exaltata*.

A small spored saprophytic *Cylindrocladium* has been isolated along with the parasite. Whether or not it should be regarded as a distinct species is unknown.

The excision of all affected fronds and their destruction appears to be the only practical means of controlling this disease.

U. S. CITRUS DISEASE FIELD LABORATORY,
ORLANDO, FLA.

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EXPLANATION OF FIGURES

PLATE 2

Fig. 1. Frond of leather leaf fern affected with brown leafspot.
Fig. 2. Petri dish culture planted at the same time with eight colonies of *Cylindrocladium*. The four bearing a profuse coating of conidiophores are those of *Cylindrocladium pteridis*. The other four are the small spored form.

PLATE 3

Figs. 1, 2, 3, 4, 6, 8, and 9 are drawn to the scale above Fig. 6. Figs. 5 and 7 are drawn to the scale near Fig. 5.
Fig. 1. Conidia of *Cylindrocladium pteridis*.
Fig. 2. Conidia of the saprophytic *Cylindrocladium* associated with *C. pteridis*.
Fig. 3. Germinating conidia of *C. pteridis*.
Fig. 4. Bead-like cells from an old hypha.
Fig. 5. Sclerotia of *C. pteridis* within the epidermis in surface section.
Fig. 6. Conidiophores or fertile hyphae of *C. pteridis*.
Fig. 7. Bundle of conidia in position on the conidiophore.
Fig. 8. Infection by the brown leafspot fungus through the upper epidermis of a young pinnule of leather leaf fern.
Fig. 9. Conidiophore of the small-spored *Cylindrocladium*.

PLATE 2

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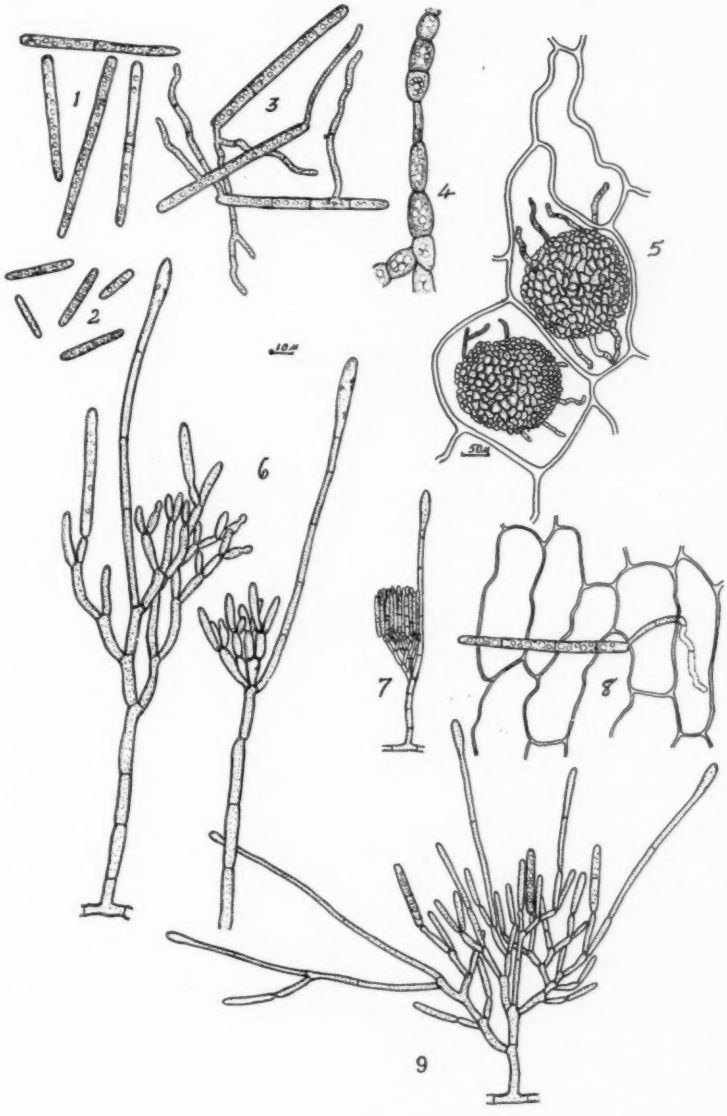
PLATE 3



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THE GENITALIA OF SOME OF THE COCCINELLIDAE[1]

By J. W. Wilson

Plates 4–6

The genitalia of insects has been sadly neglected until recently. In 1912 Sharp and Muir published a very excellent paper with illustrations on the male genital tube of the Coleoptera. Their paper included so many families that it was impossible to go into the details of any one family. In the present paper the author has described and figured the male genital tube of fifteen species of the family Coccinellidae. The descriptions of the aedeagus of these species are given in the order of the complexity of the aedeagus.

After working out the material on the male genital tube, the author thought that possibly there would be some characters of interest in the abdomen of the female. Consequently the terminal segments of the female abdomen were studied, and some very interesting results obtained.

The terminology used by Sharp and Muir has been adopted in this paper. The author also wishes to acknowledge the generous assistance of Dr. Z. P. Metcalf which has made this paper possible.

The Male Genital Tube

The genital tube of the male Coccinellidae is quite different from that of other families of Coleoptera. Verhoeff (1893) believed these differences to be of such importance that he divides the Coleoptera into two suborders, Siphonophora, including the Coccinellidae, and Asiphona, including all other Coleoptera. Weis (1894) and Sharp and Muir (1912) do not consider the characters of the genital tube alone as of such great importance.

The aedeagus of the Coccinellidae is large and long, filling a large part of the abdominal cavity. The aedeagus lies on its left side when retracted into the abdomen. In taking out the aedeagus the sternum was pulled away from the tergum leaving the aedeagus attached to the tergum. The drawings were then made from a view of the left side of the aedeagus.

[1] Published with the approval of the Director of the North Carolina Agricultural Experiment Station as paper number 10 of the Journal Series.

In all the species studied and those figured by Sharp and Muir the median lobe is long, curved and slender; the median lobe being the central curved tube (ML). In most cases the median lobe is flattened and expanded laterally at the base. The shape of this flattened area varies with the species. The long membrane is long enough to allow free movement of the median lobe. The tegmen (TG) is made up of the basal piece (BP), the lateral lobes (LL) and the basal lobe (BL). The tegmen forms a ring around the median lobe and is united on the ventral side. Projecting from the ventral side of the tegmen there is a long strut, the median strut (MS), which supports the flattened portion of the median lobe. The basal piece is the large proximal portion of the tegmen. At the sides, the lateral lobes are attached to the basal piece. The lateral lobes are long and slightly curved, bearing a few long setae at the distal end. Between the lateral lobes and attached to the basal piece there is a large sclerite which seems to be peculiar to the family Coccinellidae. The name *basal lobe* is suggested for this sclerite. This basal lobe is a large structure and in some forms it is united on the ventral surface completely surrounding the median lobe. The long membrane which is attached to the proximal end of the tegmen and connecting the aedeagus to the abdomen is the second connecting membrane (CMI). The length of the membranes allows free movement of the whole aedeagus. The ejaculatory duct is a long, very slender tube which conducts the sperm from the testis to the median orifice (MO) at the distal end of the median lobe. In most of the tribes the median lobe is long and has only one curve near the proximal end. The basal lobe and lateral lobes are long. In the tribe Epilachnini the median lobe is much longer and is curved again near the distal end. The basal lobe and lateral lobes are also longer.

Of the tribes studied, Hyperaspini contains the forms with the least complex aedeagus and the aedeagus becomes more complex in the tribes as arranged in the following order: Hyperaspini, Chilocorini, Coccinellini, Epilachnini and Hippodamnini. The aedeagus of *Olla abdomenalis plagiata* seemed to be quite distinct from that of the other species of the tribe Coccinellini. For the reasons pointed out later on the author has considered this species as separate from the species of the tribe Coccinellini.

TRIBE HYPERASPINI

Forms examined *Hyperaspis sigmata* (Oliv), figs. 1 and 2, and *Brachyacantha ursina* (Fab), fig. 3.

Hyperaspis signata, fig. 1. The aedeagus of this form seems to be the simplest of those examined. Median lobe (ML) long, slender, curved tube with the basal end flattened. Median foramen (MF) large, extending across the end of the flattened portion of the median lobe. Tegmen (TG) forming a ring around the median lobe. Projecting from the ventral surface is the median strut (MS) long and slender, supporting the flattened portion of the median lobe. Lateral lobes attached at the sides of the tegmen and extending slightly beyond end of the median lobe. Between the lateral lobes and attached to the basal piece is the basal lobe (BL). This structure is clearly a part of the tegmen as shown by figure 2. It may simply be a projection of the basal piece but it is constant and peculiar to the family Coccinellidae.

Extending from the membrane of the ninth sternite there is a long, slender structure, the epicule (SP). The origin or function of this structure is unknown.

Brachyacantha ursina, fig. 3. Flattened portion of the median lobe subrectangular, with a notch to receive the enlarged end of the median strut (MS) on the dorsal side there is a thin, flattened, chitinized projection (A). Lateral lobes (LL) large, and concave. Basal lobe (BL) broad and as long as the lateral lobes.

Spicule long, slender and curved at the distal end.

In this tube the aedeagus is small in proportion to the small size of the beetle. The basal end of the median lobe is not greatly expanded. The basal lobe is narrow, not folding around the median lobe.

TRIBE CHILOCORINI

Forms examined *Chilocorus bivulnerus* (Muls), figs. 4 and 5.

Chilocorus bevulnerus, fig. 4. Median lobe (ML) long and slender with the flattened end at right angles with the remainder of the median lobe forming a T. Basal piece (BP) large and cylindrical. Lateral lobes (LL) long and slender. Basal lobe as long as the lateral lobes, narrow and pointed at the end.

Spicule Y-shaped at distal end.

Figure 5 also shows the basal lobe to be a projection of the basal piece.

TRIBE COCCINELLINI

Forms examined *Certomegilla fuscilabris* Muls, fig. 6; *Adalia bipunctata* (L), fig. 7; *Anatis quadridecimpunctata* (Oliv), fig. 8; *Coccinella quinquenotata* Kby., fig. 11.

Ceratomegilla fuscilabris, fig. 6. Median lobe (ML) long and tapering to a small distal end. Flattened portion of median lobe deeply emarginated to receive the median strut. Basal piece (BP) long and circular. Lateral lobes (LL) long, pointed and rather broad, curving around the median lobe, but not meeting on the mid ventral lobe. The whole aedeagus rather slender.

Spicule a simple straight structure and omitted from this drawing.

Adalia bipunctata, fig. 7. Flattened portion of the median lobe subrectangular and slightly emarginated to receive the median strut. Median lobe tapering toward the distal end then suddenly becoming large at the end. Basal piece (BP) short. Lateral lobes (LL) short and slightly curved. Basal lobe (BL) slightly longer than the lateral lobes, with the apical end closed and a ridge along the dorsal surface giving it a keel-like appearance, not closed along the mid ventral line.

Spicule a simple straight structure and omitted from the drawing.

Anatis quadridecimpunctata, fig. 8. The aedeagus of this species is long and slender. Basal end of median lobe of average size, irregular in outline, and deeply emarginated near the center for the reception of the median strut (MS). Median lobe (ML) tapering toward the distal end and slightly bent ventrad at the end. Tegmen much smaller than in Coccinella. Lateral lobes (LL) and basal lobe (BL) long; basal lobe having a raised hump on the dorsal surface near the center, and lateral margins widely separated.

Spicule (SP) straight and rather wide.

Coccinella perplexa, fig. 9. Flattened end of median lobe very large, with the median foramen extending its whole length, and the median strut (MS) fitting in the slight emargination near the center. Median lobe tapering to a small distal end. Tegmen large with the dorsal portion of the basal piece (BP) extending craniad to a sharp point. Lateral lobes (LL) short. Basal lobe (BL) broad with the sides folding around the median lobe, but widely separated on the ventral surface, pointed at the end.

Spicule slender but rather crooked.

Coccinella novemnotata, fig. 10. The aedeagus of this species is longer and less bulky than *C. perplexa*. Flattened end of the median lobe rather large, with a flat chitinized expanded area (A) on the dorsal side. Median lobe (ML) about the same size throughout its whole length. Basal piece (BP) extends craniad to a point as in *Coccinella perplexa*. Basal lobe (BL) distinctly longer than the lateral lobes.

Spicule slightly larger at the distal end than at the base.

Coccinella quinquenotata, fig. 11. The aedeagus of this species is long and large. Basal end of the median lobe large and irregular in outline, with a flattened expanded area on the dorsal side. Median lobe (ML) long, becoming slightly larger at the distal end. The basal piece extends further craniad than in the other two species. Lateral lobes (LL) rather long. Basal lobe (BL) is very large, surrounding the median lobe but not united on the ventral surface. The dorsal surface more heavily chitinized than the lateral surfaces, deeply notched, and pointed at the end.

The aedeagus in this genus is rather large; basal end of median lobe large, and irregular in outline; tegmen large with the basal piece pointed; basal lobe large but not forming a complete tube around the median lobe.

The members of the tribe Coccinellini show clearly a gradual increase in complexity of the aedeagus from *Ceratomegilla fuscilabris* through the series *Adalia bipunctata*, *Anatis quadridecimpunctata*, *Coccinella perplexa*, *Coccinella novemnotata*, to *Coccinella aquinquenotata*. The basal end of the median lobe becomes larger. In the first species of the series the median lobe tapers toward the distal end. In the last two species it remains about the same size throughout. The enlarged distal end of *Adalia bipunctata* may be a permanent evagination of the internal sack. It is at least constant, for several specimens were examined. The tegmen gradually becomes larger and more complex until we have the conditions as found in *C. quinquenotata*. The second connecting membrane extends to the end of the median strut while in Chilocorini it appeared to be attached at the base of the median strut.

Olla abdomenalis plagiata, fig. 12. Basal end of the median lobe narrowly flattened and extending in a dorso-ventral direction, with a small emargination for the reception of the median strut (MS). On the dorsal side there is a small, thin, chitinized area (A) as in Coccinella but much smaller. Median lobe (ML) long, and about the same size throughout except near the distal end. The distal end is divided into two subequal prongs, the dorsal prong being bent back over the basal lobe and fitting in a groove in the basal lobe. The ventral prong bent and bearing the median orifice (MO). Basal piece (BP) extending craniad to a point. Basal lobe (BL) long and almost surrounding the median lobe but not joining on the ventral surface, shaped much as the basal lobe in Epilachna. Lateral lobes long, and expanded at the distal end.

Spicule a very small, slender filament projecting from the membrane of the ninth segment, omitted from the drawing.

This form is placed in the tribe Coccinellini by systematists but due to the peculiar structure of the aedeagus it should, perhaps, be considered as separate from the tribe Coccinellini. The basal end of the median lobe resembles to a slight degree that of Coccinellini. The basal piece and median strut resemble these parts in Coccinellini. Because of these resemblances it is placed next Coccinellini. The length of the median lobe, basal lobe, lateral lobes and shape of the basal lobe would suggest a resemblance to Epilachnini.

TRIBE EPILACHNINI

Forms examined *Epilachna borealis* (Fab), fig. 13, and *Epilachna corrupta* (Muls), fig. 14.

Epilachna borealis, fig. 13. Median lobe (ML) long, curved near the basal end and again near the distal end, and about the same size throughout. Basal end of the median lobe only slightly expanded. Basal piece (BP) large and transverse. Median strut expanded and grooved to fit in with the median lobe. Basal lobe (BL) long and surrounding the median lobe but not forming a complete tube. Lateral lobes (LL) long and narrow.

Spicule (SP) a simple, long and narrow structure.

Epilachna corrupta, fig. 14. The basal end of the median lobe in this species not expanded, but resembles that of Hippodamia somewhat. A small projection from the ventral side of the median lobe seems to serve as a stop for the median strut. Tegmen about the same as in *E. borealis*.

Leng (1920) separates the genus Epilachna as a subfamily. Considered from the standpoint of the aedeagus it seems that it should be given tribal rank, placing it between *Olla abdomenalis plagiata* and and Hippodamini. The resemblances between *Olla abdomenalis plagiata* and Epilachnini have already been pointed out. The further reduction of the basal end of the median lobe and the approximation of the margins of the basal lobe suggest resemblances to Hippodamini.

TRIBE HIPPODAMINI

Forms examined *Hippodamia parenthesis* (Say), fig. 15, *Hippodamia convergens* (Guer), fig. 16, and *Hippodamia tridecimpunctata* (L), fig. 17.

Hippodamia parenthesis, fig. 15. Median lobe (ML) curved very sharply near the basal end. Near the basal end and on the ventral side there is a projection which apparently serves as a stop for the median strut (MS). A small flap-like projection (A) extends from the basal end

of the median lobe. Median lobe about the same size throughout except near the distal end where it suddenly tapers to a small median orifice (MO). Basal piece (BP) large and pointed on the dorsal surface, connected on the ventral surface by the base of the median strut. Median strut expanded at the distal end, with a depression to receive the median lobe. Lateral lobes (LL) broad, basal lobe (BL) fused on the ventral surface for a short distance. Dorsal and lateral surfaces of the basal lobe well chitinized.

It will also be noticed in the genus Hippodamia that there is no spicule projecting from the membrane of the ninth segment; however, there is a slight protrusion of the membrane which may be homologous with the spicule.

Hippodamia convergens, fig. 16. Median lobe (ML) shaped much like that of *H. parenthesis*. Basal piece (BP) large and pointed on the dorsal surface, on the ventral side it meets and with the basal lobe (BL) forms a complete tube around the median lobe. On the lateral surfaces this structure is deeply emarginated and the dorsal and ventral surfaces pointed. Median strut enlarged toward the distal end and grooved to receive the median lobe. Lateral lobes (LL) narrow.

Hippodamia tridecimpunctata, fig. 17. The aedeagus of this form is very irregular in shape, with a much larger area near the distal end. Basal piece very large and transverse. The basal piece and basal lobe form an emarginated tube around the median lobe. Lateral lobes broad and without setae.

Casey (1899) and others place Hippodamia, Ceratomegilla (Megilla) and other genera in the tribe Hippodamini. Leng (1920) places all of these genera in the tribe Coccinellini. On account of the structure of the aedeagus the genus Hippodamia is here separated from Coccinellini and given tribal rank. It will be noticed that Ceratomegilla is left in the tribe Coccinellini. The median lobe of Hippodamia lacks the broad expanded basal end, but has a small characteristic flap at the end. The tegmen is large and fuses on the ventral surface in two species and is fused for a short distance in the other. The median strut is stout and expanded at the end with a groove to receive the median lobe.

Hippodamia tridecimpunctata is the more complex of the three as is easily seen by comparing the drawings. It is also the most complex of the species studied.

TERMINAL ABDOMINAL SEGMENTS OF THE FEMALE

As a general rule it has been found that the females of a group are rather uniform in structure, there being very little difference between species and even higher groups. However, the species studied in preparing this paper showed quite distinct differences between species of the same genus.

The abdomen was removed and boiled in caustic potash to remove the color. The ninth and tenth segments were then removed and the drawings were made from a ventral view of the segments. The membrane connecting the chitinized lateral portion of the ninth segment was removed.

In the female, the ninth and tenth segments are drawn into the abdomen as in the male. The membrane which connects the ninth segment with the eighth is long to allow the ninth segment to be drawn into the abdomen. The tergite and sternite of the ninth segment are short, thin and membranous. The lateral portions of the ninth segment are well chitinized. The anal opening is located ventrad of the tenth tergite. Immediately above the tenth sternite is the vaginal opening. Between the vaginal and anal opening there is a thick membrane which is attached at the sides to the ninth segment. This membrane is probably the remains of the eleventh segment.

The description of the female segments is given in the same order as that of the male aedeagus.

Hyperaspis signata (Oliv), fig. 18. Lateral surface of the ninth segment well chitinized. The tenth sternite is divided into two subrectangular genital plates (GP). The setae along the distal edge have fused to form a membranous projection of the plates. Tenth tergite short and well chitinized.

Brachyacantha ursina (Fabr), fig. 19. The terminal segments of the female seem to represent the most primitive condition of all the females. The tenth sternite is deeply emarginated or the genital plates (GP) have united so that the tenth sternite is no longer divided as in the other females. At the distal end of the two plates the setae have apparently fused as in *Hyperaspis signata*.

Chilocorus bivulnerus (Muls), fig. 20. Ninth segment (9SG) well chitinized almost the whole width of the sternite, with small membranous areas on the lateral surfaces (A). Genital plates (GP) very long, bearing small genital tubercles (GT) at the distal end, and overlapping slightly. Tenth tergite unusually long, and bearing a large number of setae.

Ceratomegilla fuscilabris (Muls), fig. 21. The genital plates (GP) of this form resembles in general outline the genital plates of Hypodamia somewhat. The arms of the plates are rather slender with the distal ends large and bearing large genital tubercles (GT). The genital tubercles bear several setae. The genital plates overlap slightly in the center.

Adalia bipunctata (L), fig. 22. Genital plates (GP) pear shaped, rather widely separated on the median line, bearing a large genital tubercle (GT) at the distal end. The parts are actually larger than in *Ceratomegilla fuscilabris* but the drawing of *A. punctata* was made with a lower magnification.

Anatis quadridecimpunctata (Oliv), fig. 23. The chitinized lateral portions of the ninth segment (9SG) long, and pointed at the base. Genital plates (GP) long and bear a small genital tubercle (GT) at the distal end.

Coccinella perplexa (Muls), fig. 24. Genital plates (GP) large, pear shaped, and bearing a large genital tubercle (GT). The genital plates do not overlap at the median line.

Cycloneda munda (Say), fig. 26. Genital plates (GP) rather large and overlapping on the median line. The plates are shaped quite differently from those of Coccinella. Genital tubercle small.

Olla abdomenalis plagiata (Csy), fig. 27. Chitinized portion of the ninth segment large and long. Genital plates small and do not bear a genital tubercle, but bear a few short setae.

Epilachna borealis (Fabr), fig. 28. Genital plates fused at the base and joined to the ninth segment. At the base and on the median line there is a slight depression which arises at the opening between the two plates. This depression is shallow and does not extend the entire length of the plates. The plates bear at the distal end large genital tubercles (GT). Figure 29 shows the tenth tergite which is a single large plate.

Epilachna corrupta (Muls), fig. 30. Genital plates (GP) do not unite at the base as in *E. borealis*. There is a depression in each plate on the inner margin forming a groove. This groove is probably the egg guide. Genital tubercles not present.

The diagram (fig. 31) shows the arrangement of the terminal abdominal segments in cross section.

Hippodamia parenthesis (Say), fig. 32. Genital plates (GP) rather long with arm-like projections at the base which attach to the ninth segment. Distal ends of the plates expanded and bearing a small

genital tubercle (GT). The genital plates do not meet at the median line. The general shape of the plates is characteristic for the genus.

Hippodamia glacialis (Fabr), fig. 33. Genital plates (GP) large and broad; arms at the base narrow and long. Genital tubercle small.

Hippodamia convergens (Guer), fig. 34. Genital plates large, irregular in outline and meeting at the median line, but not overlapping. On the inner margin there is a slight depression on each plate. Genital tubercle small, tenth tergite short, well chitinized and bearing many setae.

Hippodamia tridecimpunctaia (L), fig. 35. Genital plates (GP) not as irregular in outline as *H. convergens*. The plates are long, extending to the edge of the tenth tergite. Genital tubercles located in large, shallow depressions.

In arranging the plates of the female in the order of their complexity, there appeared to be many conflicts with the arrangement according to the aedeagus. Since the male genital tube is considered to be more stable, the females were arranged in the same order as the males.

The first difficulty arises when the genital plates of *Hyperaspis signata* and *Brachyacantha ursina* are compared. The genital plates of *Hyperaspis signata* are entirely separated while the plates of *Brachyacantha ursina* are united, which appears to be the more primitive condition.

The plates of *Chilocorus bivulnerus* show no relation at all to either *Hyperaspis signata* or *Brachyacantha ursina*.

A study of the Coccinellini is indeed perplexing. Instead of *Ceratomegilla fuscilabris* having any resemblances to *Chilocorus bivulnerus*, it has none. The shape of the plates of *Ceratomegilla fuscilabris* would indicate that it belonged close to Hippodamia, but the aedeagus gives no hint of any such relation. The large chitinized lateral portion of segment nine and the long genital plates of *Anatis quadridecimpunctata* with *Coccinella perplexa* and *Coccinella novemnotata* following. *Cycloneda munda* would naturally follow *Coccinella novemnotata*.

When we come to *Olla abdomenalis plagiata* we strike another problem. It is apparently neither related to *Cycloneda munda* on the one side nor *Epilachna borealis* on the other.

The genital plates of the Epilachnini with the groove at the median line are clearly the most complicated of all the species studied.

The Hippodamini would also fit in very nicely between Coccinellini and Epilachnini.

STATE COLLEGE,
RALEIGH, N. C.

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WEISSE, JULIUS. D. E. Z. 155–157 and D. E. Z. 177–188. 1894.

EXPLANATION OF PLATES

LIST OF ABBREVIATIONS USED IN PLATES

Basal lobe	BL
Basal piece	BP
Eighth segment	8SG
Ejaculatory duct	EJ
First connecting membrane	CMI
Genital plates	GP
Genital tubercles	GT
Lateral lobe	LL
Median foramen	MF
Median lobe	ML
Median orifice	MO
Ninth segment	9SG
Second segment membrane	CM2
Spicule	SP
Sternites	S8, S9, S10
Tegmen	TG
Tenth segment	10SG
Tergites	T8, T9, T10

PLATE 4

Fig. 1. Male genital tube of *Hyperaspis signata*.

Fig. 2. Male genital tube of *Hyperaspis signata* with the second connecting membrane removed and the tegmen pulled apart on the ventral surface.

Fig. 3. Male genital tube of *Brachyacantha ursina*.

Fig. 4. Male genital tube of *Chilocorus bivulnerus*.

Fig. 5. Male genital tube of *Chilocorus bivulnerus* with the second connecting membrane removed and the tegmen pulled apart on the ventral surface.

Fig. 6. Male genital tube of *Ceratomegilla fuscilabris*.

Fig. 7. Male genital tube of *Adalia bipunctata*.

Fig. 8. Male genital tube of *Anatis quadridecempunctata*.

Fig. 9. Male genital tube of *Coccinella perplexa*.

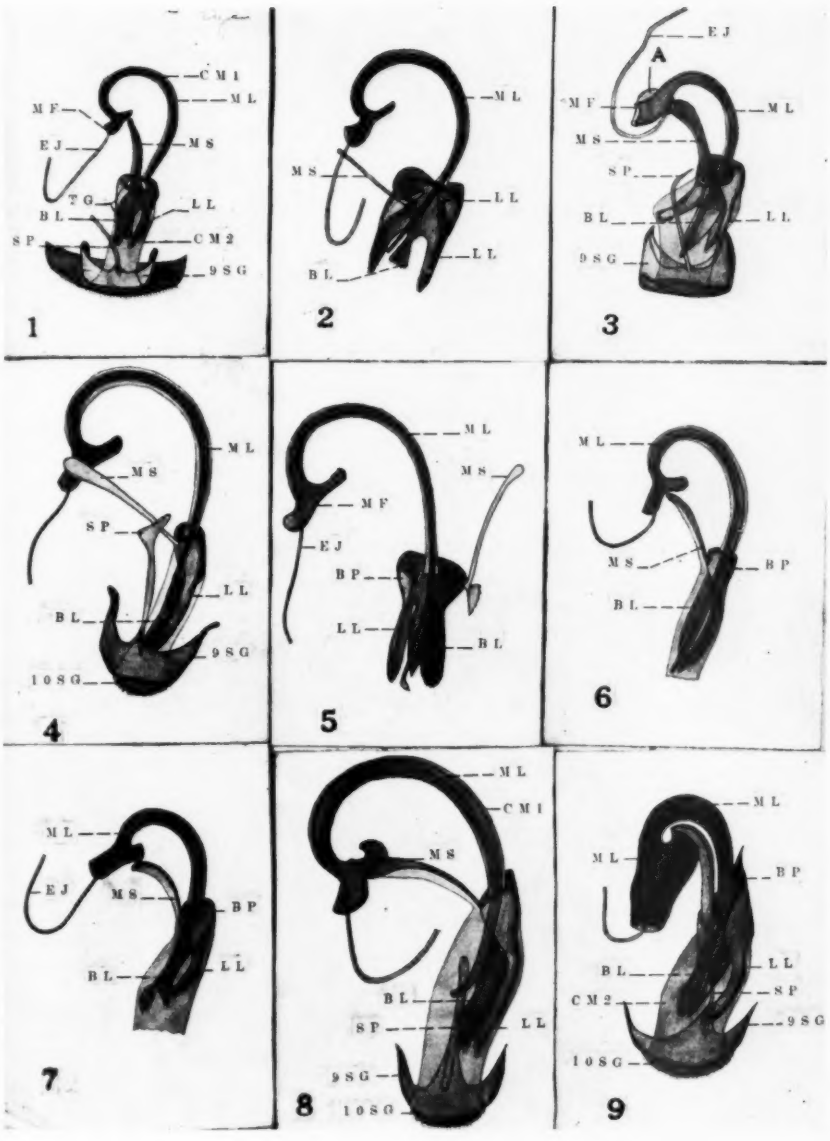
PLATE 5

Fig. 10. Male genital tube of *Coccinella novemnotata.*
Fig. 11. Male genital tube of *Coccinella quinquenotata.*
Fig. 12. Male genital tube of *Olla abdomenalis plagiata.*
Fig. 13. Male genital tube of *Epilachna borealis.*
Fig. 14. Male genital tube of *Epilachna corrupta.*
Fig. 15. Male genital tube of *Hippodamia parenthesis.*
Fig. 16. Male genital tube of *Hippodamia convergens.*
Fig. 17. Male genital tube of *Hippodamia tridecimpunctata.*

PLATE 6

Fig. 18. Terminal abdominal segments of female *Hyperaspis signata.*
Fig. 19. Terminal abdominal segments of female *Brachyacantha ursina.*
Fig. 20. Terminal abdominal segments of female *Chilocorus bivulnerus.*
Fig. 21. Terminal abdominal segments of female *Ceratomegilla fuscilabris.*
Fig. 22. Terminal abdominal segments of female *Adalia bipunctata.*
Fig. 23. Terminal abdominal segments of female *Anatis quadridecimpunctata.*
Fig. 24. Terminal abdominal segments of female *Coccinella perplexa.*
Fig. 25. Terminal abdominal segments of female *Coccinella novemnotata.*
Fig. 26. Terminal abdominal segments of female *Cycloneda munda.*
Fig. 27. Terminal abdominal segments of female *Olla abdominalis plagiata.*
Fig. 28. Terminal abdominal segments of female *Epilachna borealis.*
Fig. 29. Terminal abdominal segments of female *Epilachna borealis* from a dorsal view.
Fig. 30. Terminal abdominal segments of female *Epilachna corrupta.*
Fig. 31. Terminal abdominal segments of female *Epilachna corrupta* from a dorsal view.
Fig. 32. Terminal abdominal segments of female *Hippodamia parenthesis.*
Fig. 33. Terminal abdominal segments of female *Hippodamia glacialis.*
Fig. 34. Terminal abdominal segments of female *Hippodamia convergens.*
Fig. 35. Terminal abdominal segments of female *Hippodamia tridecimpunctata.*

PLATE 4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MF
EJ
MS
TG
LL
BL
SP
CM2
9SG
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ML
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EJ
A
MF
ML
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9SG
3
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ML
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7
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CM1
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9

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PLATE 5

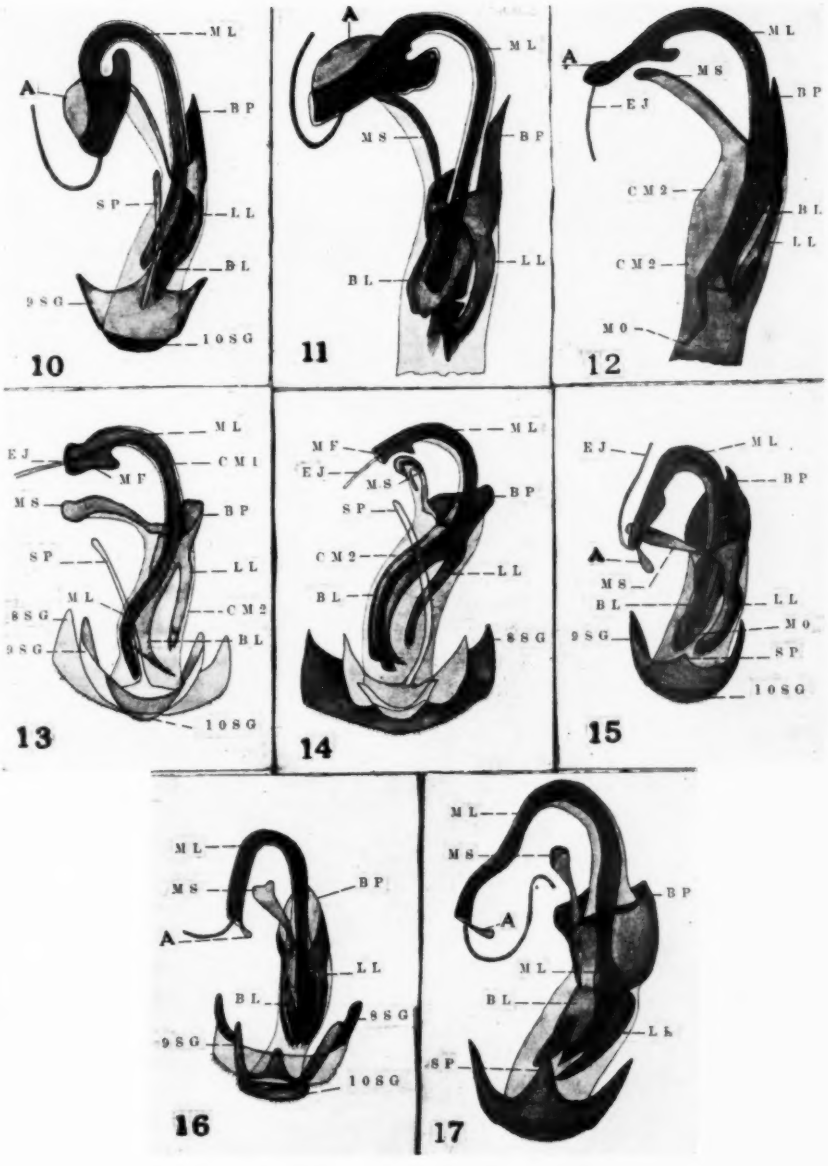
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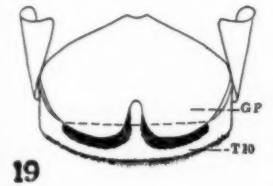
PLATE 6

18



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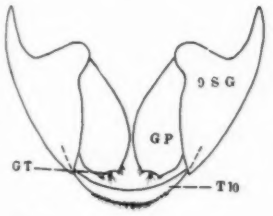

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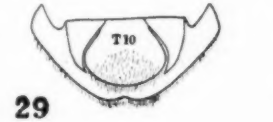

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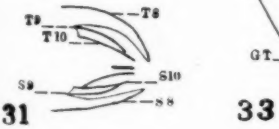

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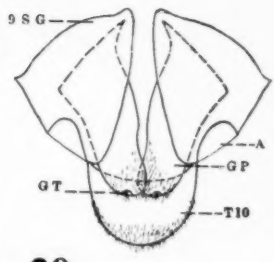

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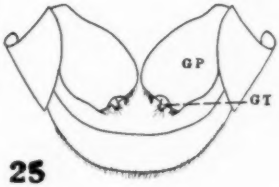

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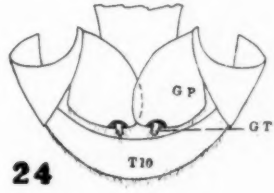

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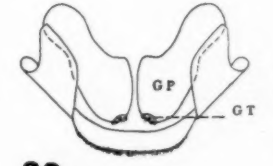

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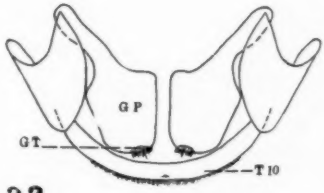

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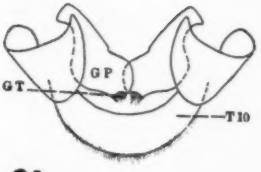

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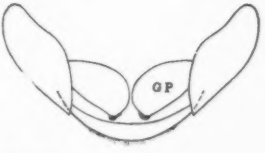

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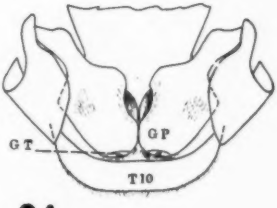

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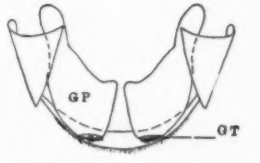

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REVISED KEY AND LIST OF THE AMPHIBIANS AND REPTILES OF NORTH CAROLINA

By C. S. Brimley

This key is intended to replace those published in the Mitchell Journal for December, 1907, as additional records and descriptions of new species have made those keys obsolete, particularly for the salamanders. The turtles were omitted from the 1907 keys but are included in these.

Only species occurring or likely to occur in North Carolina are included and in order to make the key more useful, letters are placed in parentheses after the name of each species to indicate its known distrition within the state. These letters are,—

SW., indicating a state-wide distribution.
E., indicating occurrence in the eastern district.
C., indicating occurrence in the central district.
M., indicating occurrence in the mountain region generally.
MV., indicating occurrence in the mountain valleys.
"NC.," indicating state record without definite locality.

The North Carolina species are numbered serially, but those not yet recorded from the state are unnumbered and are followed by the name of the nearest state from which they are known.

Key to the Groups of Amphibians and Reptiles

1. Skin never with scales or plates; at least one pair of limbs present: digits never with claws or nails. Amphibians.... 2
   Skin covered with scales or plates, except in a few turtles, limbs present or absent, but if present always with claws or nails on at least some of the digits. Reptiles..... 3
2. Tail present in adults. Group I, Salamanders.
   Tail absent in adults. Group II, Frogs and Toads.
3. Body enclosed in a bony shell or carapace, teeth absent. Group VI, Turtles
   Body without a carapace, teeth present..... 4
4. Without limbs, movable eyelids or external ears. Group V, Snakes.

Limbs, except in the lizard *Ophisaurus*, movable eyelids and external ears present..... 5

5. Vent a cross-slit, body covered with small scales, tail rounded. Group IV, Lizards.

Vent longitudinal, body with large bony plates, tail flattened in a vertical plane. Group III, Crocodiles.

GROUP I. THE SALAMANDERS

1. External gills present in adults, digits four or less..... 2

External gills absent in adults..... 4

2. Form eel-like, hind limbs absent..... 3

Form salamander-like, hind limbs present..... 3A

3. Body unstriped, size large, toes four. (1.). Great Siren, Mud Eel (*Siren lacertina*) (E.).

Body striped, size small, toes three. Little Siren (*Pseudobranchus striatus*) (SC.).

3A. Body with dark markings above and often also below, length 8 inches or less. (2.). Southern Water Dog (*Necturus maculosus lewisi*) (Wake, Edgecombe, Orange and Lenoir counties).

Wholly without dark markings, smaller than preceding. (3.). Carolina Water Dog (*Necturus punctatus*) (Wake, Harnett, Sampson and New Hanover).

4. A rounded opening or spiracle on each side of neck, no movable eyelids..... 5

No such spiracle, eyelids movable..... 6

5. Form eel-like, limbs very small with two toes each. (4.). Ditch Eel (*Amphiuma means*) (E.).

Form salamander-like, limbs normal with four toes on the front feet, and five on the hind ones. (5.). Hellbender (*Cryptobranchus alleghaniensis*) (M.)

6. No costal grooves, head with longitudinal ridges..... 7

Costal grooves present..... 8

7. Sides with a series of round, black-bordered red spots. (6.). Common Newt (*Triturus viridescens*) (SW.).

Sides with a series of more or less broken red lines, edged above and below with black. (7.). Wilmington Newt (*Triturus viridescens dorsalis*) (Scotland, New Hanover).

8. Teeth on the roof of the mouth in transverse series only, all the toes well developed..... 9

Teeth in roof of mouth in longitudinal series (parasphenoids) and usually also with a transverse series anterior to them.... 15

9. Costal grooves 11 or less..... 10
   Costal grooves 12 or more..... 12
10. Color brown or black without well defined markings; head broad and rather flat; tongue without a median groove and with its folds radiating from behind. (8.). Mole Salamander (*Ambystoma talpoideum*) (Henderson Co.).
    Markings prominent and well defined..... 11
11. Upper parts with a row of round yellow spots down each side of back, under-parts paler than upper parts. (9.). Spotted Salamander (*Ambystoma maculatum*) (E, C, M.).
    Upper parts marked with large gray or white markings, underparts black, unmarked. The young when just transformed are lead colored with one or two rows of pale spots down each side. (10.). Marbled Salamander (*Ambystoma opacum*) (E, C.).
12. Back with narrow gray cross-bars, underparts speckled with gray. Banded Salamander (*Ambystoma cingulatum*) (SC.).
    Back without gray cross bars..... 13
13. With irregular yellow markings. (11.) Tiger Salamander (*Ambystoma tigrinum*) (Lee).
    With whitish or grayish markings..... 14
14. Tongue with oblique rows of papillae running out on each side from the median furrow. (127.). Small-mouthed Salamander (*Ambystoma microstomum*) (Harnett).
    Tongue without such rows of papillae. Jefferson Salamander (*Ambystoma jeffersonianum*) (Va.).
15. Tongue a circular disk on a central stalk..... 16
    Tongue attached in front as well as in center..... 26
16. Toes on hind foot four, length 3 inches or less, brownish yellow with a dark shade down each side of back. (12.). Dwarf Salamander (*Manculus quadridigitatus*) (E.).
    Toes on hind foot five, size larger..... 17
17. Color yellow striped or spotted with darker, tail as long as or much longer than head and body..... 18
    Color red or reddish, not striped, tail not longer than head and body..... 21
18. Tail usually but little longer than head and body, a dark stripe down each side of body, underparts unmarked..... 19
    Tail 1½ to 2 times as long as head and body..... 20

19. Dark stripes on sides of body extending on tail nearly to tip. (13.). Southern Striped Salamander (*Eurycea bislineata cirrigera*) (E, C.).
    Dark stripes only extending on to base of tail. (14.). Mountain Striped Salamander (*Eurycea bislineata wilderae*).
20. A stripe down middle of back and one down each side, underparts marbled with black. (15.). Holbrook's Salamander (*Eurycea guttolineata*) (E, C, MV.).
    Back and sides with numerous black spots, underparts unmarked. (16.). Long-tailed Salamander (*Eurycea longicauda*) (Haywood).
21. A light line from eye to nostril, snout truncate..... 22
    No light line from eye to nostril, snout rounded..... 23
22. A dark as well as light line from eye to nostril, upper parts with distinct flecks or spots. (17.). Daniel's Salamander (*Gyrinophilus danielsi*) (M.).
    A light line only from eye to nostril, upper parts unspotted. Purple Salamander (*Gyrinophilus porphyriticus*) (Va.).
23. Parasphenoid patches approximated in front, usually diverging behind, black spots on upper parts scattered, never confluent. (18.). Baird's Red Salamander (*Pseudotriton montanus* (E, C.).
    Parasphenoid patches well separated, parallel, head broader and more flattened than in preceding..... 24
24. Spots on back considerably coalescent, lower jaw with little black. (19.). Red Salamander (*Pseudotriton ruber ruber*) (E, C.).
    Spots on back well separated..... 25
25. Lower jaw almost wholly black, tail well spotted. (20.). Schenck's Red Salamander (*Pseudotriton ruber schencki*) (Mountains south of Asheville, N. C.).
    Little or no black on lower jaw, tail scantily or not at all spotted. (21.). Dunn's Red Salamander (*Pseudotriton ruber nitidus*) (Mountains north of Asheville, N. C.).
26. Toes on hind foot four, underparts white with black spots. Scaly Salamander (*Hemidactylium scutatum*) (Va., S. C.).
    Toes on hind foot five..... 27
27. Tail more or less finned or keeled above or else a light line backward from eye to corner of mouth, more or less aquatic species never blue black in color..... 28

Tail rounded, never finned or keeled, no light line backward from eye to angle of jaw, terrestrial species..... 34

28. Head with enlarged pores giving it a pitted appearance, sides with broken lines, underparts usually with dark specks. (22.). Margined Salamander (*Stereochilus marginatus*) (E.).

Otherwise..... 29

29. Internal nostrils inconspicuous, twice as far apart as external nostrils, color yellowish brown, mottled. (23.). Moore's Salamander (*Leurognathus marmoratus*) (Watauga, Avery and Haywood counties).

Internal nostrils conspicuous and about as far apart as external nostrils..... 30

30. Tail rounded, underparts mottled but the belly in old specimens sometimes entirely black. (24.). Round-tailed Desmognath (*Desmognathus carolinensis*) (M.).

Tail finned or keeled above..... 31

31. Underparts uniform in color..... 32

Underparts mottled..... 33

32. Underparts black or slate color, tail shorter than head and body. (25.). Black Desmognath (*Desmognathus quadrimaculatus*) (M.).

Underparts light, tail longer than head and body. (26.). Mountain Desmognath (*Desmognathus phoca*) (M.).

33. Paler, the light predominating below. (27.). Common Desmognath (*Desmognathus fuscus fuscus*) (C.).

Darker, the dark color predominating below. (28.). Southern Desmognath (*Desmognathus fuscus auriculatus*) (E.).

34. Legs red, no other markings. (29.). Red legged Salamander (*Plethodon shermani*) (Wayah Bald Mt., Macon County).

Legs not red..... 35

35. Body without markings behind the front legs..... 36

Body with markings behind the front legs..... 39

36. Costal grooves 19, belly mottled. (30.). Red-backed Salamander (*Plethodon cinereus*), plain form. (Mts., also Wake and Pitt.)

Costal grooves 14, belly unmottled..... 37

37. Sides of head and neck back of eyes abruptly orange or pale as compared with upper surface of same. (31.). Red-necked Salamander (*Plethodon jordani*) (Haywood County).

Sides of head and neck back of eyes with the paler color of the

underparts fading imperceptibly into darker color of upperparts. (32.). Metcalf's Salamander (*Plethodon metcalfi*) (M.).

38. Back with a chestnut stripe running from head to tail..... 39
Back without such a stripe..... 40

39. Costal grooves 19, belly mottled, size small, without markings other than the dorsal stripe. (30.). Red-backed Salamander (*Plethodon cinereus*) (Mts., also Pitt and Wake).
Costal grooves 14, belly not mottled, many small white spots on sides, size large. (Stripe evanescent in preservative.) (33.). Yonahlossee Salamander (*Plethodon yonahlossee*) (Avery, Burke, Watauga, Ashe).

40. Spots yellowish green, much thickest on the back. Bronzed Salamander (*Aneides aeneus*) (Va., Tenn., S. C.).
Spots white or gray, thickest on sides..... 41

41. Throat mottled. (34.). Slimy Salamander (*Plethodon glutinosus*) (SW.).
Throat white. (33.). Yonahlossee Salamander, preserved specimens, but these very hard to tell from the preceding and I am by no means sure that the difference in the throat markings is distinctive.

GROUP II. FROGS AND TOADS

1. Parotoid glands (elongate swellings on sides of head and neck just back of eyes) present..... 2
No parotoid glands..... 6

2. Hind feet fully webbed, maxillaries with teeth. (35.). Solitary Spadefoot (*Scaphiopus holbrooki*) (Wake, Carteret, Henderson).
Hind feet scarcely or not at all webbed, maxillaries toothless... 3

3. Size small, length of adult only $1\frac{1}{4}$ inches, a white line down middle of back, skin very rough especially on legs. (36.). Dwarf Toad (*Bufo quercicus*) (Craven, Carteret, Duplin, Edgecombe, Lenoir, New Hanover).
Size larger, adult about 3 inches in length of head and body when adult..... 4

4. Bony crests on top of head elevated behind and ending in a knob, color usually dark and breast unspotted. (37.). Southern Toad (*Bufo terrestris*) (Washington, Jones, Onslow, New Hanover, Cumberland, and Scotland).
Bony crests not elevated nor knobbed behind..... 5

5. Chest spotted, color usually dark. (38.). American Toad (*Bufo americanus*) (M.).
   Chest unspotted, color usually light. (39.). Fowler's Toad (*Bufo fowleri*) (SW.).
6. A transverse fold of skin across neck just behind eyes, snout sharp, legs very short, unwebbed, size small, color dark. (40.). Narrow-mouthed Toad (*Gastrophryne carolinensis*) (E.).
   No such fold of skin across back of head 7
7. Toes and fingers with well developed viscous disks..... 8
   Toes and fingers without evident viscous disks..... 15
8. Skin of back rough..... 9
   Skin of back smooth..... 10
9. A white spot below eye, skin of back with scattered warts, markings of back irregular, not in form of numerous dark spots. (41.). Common Tree Frog (*Hyla versicolor*) (SW.).
   No white spot under eye, skin of back evenly granulated, markings in form of numerous dark spots. Florida Tree Frog (*Hyla gratiosa*) (SC.).
10. Back with a dark X-shaped mark, size small. (42.). Spring Peeper (*Hyla crucifer*) (SW.).
    Back without an X-shaped mark..... 11
11. Back of thighs with yellow spots or variegations..... 12
    Back of thighs without yellow spots or variegations..... 13
12. A plum-colored band along sides of head and body with a white line above it. (43.). Anderson Tree Frog (*Hyla andersoni*) (Moore).
    Sides not so marked. (44.). Pine-woods Tree Frog (*Hyla femoralis*) (Craven, Onslow, New Hanover).
13. Legs very long and slender, no dark spots on back..... 14
    Legs of normal length, back with dark spots, an ill defined white line along upper jaw and sides of body. (45.). Southern Tree Frog (*Hyla squirella*) (Cape Hatteras, Craven, Brunswick, New Hanover).
14. A sharply defined white line along upper jaw and sides of body. (46.). Green Tree Frog (*Hyla cinerea*) (Cape Hatteras, Lenoir, Camden, Craven, New Hanover).
    No line at all along sides of bead and body. Virginia Tree Frog (*Hyla evittata*) (Va.).
15. Toes webbed at base or not at all..... 16
    Toes full webbed or nearly so..... 18

16. Snout truncate in side view, adult about two thirds of an inch in length of head and body. (47.). Little Chorus Frog (*Pseudacris ocularis*) (Pitt, Craven, New Hanover).
    Snout rounded in side view, length a little over an inch. (48.). Common Chorus Frog (*Pseudacris feriarum*) (Wake, Guilford, Orange, Vance).
17. Size small, length about an inch, no raised fold down each side of back, tympanum indistinct 18
    Larger, tympanum distinct 19
18. Head longer than wide, femoral stripe more distinct. (49.). Cricket Frog (*Acris gryllus*) (E.).
    Head about as wide as long, snout blunter and femoral stripe less distinct. (50.). Northern Cricket Frog (*Acris crepitans*) (C, E in part).
19. A narrow raised fold down each side of back 20
    No evident fold down each side of back.
20. With a black ear patch. (51). Wood Frog (*Rana silvatica*) (Ashe, Watauga).
    No black ear patch 21
21. The dorso-lateral folds same color as rest of back, no smaller longitudinal folds between them 22
    The folds lighter colored than back and sides and with smaller longitudinal folds between them 23
22. Back with small dark spots or none, not warty between the lateral folds. (52.). Spring Frog (*Rana clamitans*) (SW.).
    Back with many roundish dark spots and small dots, and with many warts between the lateral folds, legs short, the length to heel shorter than head and body. Gopher Frog (*Rana aesopus*) (SC.).
23. Head short and snout much rounded, no round white spot at center of tympanum. Leopard Frog (*Rana pipiens*) (Va.).
    Head long and snout comparatively sharp, a round white spot at center of tympanum. (53.). Southern Leopard Frog (*Rana sphenocephala*) (E.).
24. Back with square black spots usually in two rows, under side of hind legs bright yellow in life, fading in preservative. (54.). Pickerel Frog (*Rana palustris*) (SW.).
    Back without squarish black spots 25
25. Back with a more or less distinct yellow stripe down each side. (55.). Sphagnum Frog (*Rana virgatipes*) (Washington, Moore, Cumberland, Craven, New Hanover).
    Back not striped. (56.). Bullfrog (*Rana catesbiana*) (SW.).

GROUP III. CROCODILIA, THE CROCODILES

Contains a single species native to this state as well as a number more in other parts of the world.

Our species is (57.). Alligator (*Alligator missippiensis*) (Craven, Bladen, Onslow, New Hanover, Brunswick, Robeson, Carteret, Pamlico, Washington, Lenoir).

GROUP IV. LIZARDS

1. Limbs absent, external ear and movable eyelids present. Length of adult about 24 inches of which about two-thirds is tail. (58.). Glass or Joint Snake (*Ophisaurus ventralis*) (E, also Orange and Iredell).

   Limbs present, length adult less than twelve inches..... 2

2. Surface rough or opaque..... 3

   Surface smooth and shiny..... 5

3. With lengthwise yellow stripes, scales of the belly in transverse series. (59.). Sand Lizard (*Cnemidophorus sexlineatus*) (E, C.).

   Not striped lengthwise..... 4

4. Scales granular, color uniform green or brown, toes dilated. (60.). Green Lizard, "Chameleon," (*Anolis carolinensis*) (E, also Stanly and Tryon).

   Scales larger, not granular, mostly keeled and sharp-pointed; either with dark crossbars above (female) or with blue on throat and sides (male). (61.). Fence Lizard (*Sceloporus undulatus*) (E, C, MV.).

5. Under 5 inches long, with a dark band along each side, but no light stripes. (62.). Ground Lizard (*Leiolepisma laterale* (E, C.).

   With light stripes or else over 5 inches long..... 6

6. Scales on body in 24 to 26 rows, no median light stripe, but two light stripes down each side with the intervening space black. (63.). Coal Skink (*Eumeces anthracinus*) (Pisgah Forest).

   Scales on body in 28 or more rows, young specimens black above with 5 white stripes and a blue tail, the color and markings fading with age, old males being wholly plain olive unmarked with a red head. Reaches a length of nearly 12 inches. (64.). Blue-tailed Lizard, "Red-headed Scorpion" (*Eurieces fasciatus*) (SW.).

GROUP V. SNAKES

1. A pit or hollow on each side of head between eye and nostril, plates on under-side of tail mostly unpaired, head much broader than the neck, upper jaw with an erectile poison fang on each side in front 2
   No pit on sides of head, plates on under-side of tail in pairs 6
2. Tail with a rattle 3
   Tail without a rattle, top of head covered with large plates 5
3. Top of head covered with large plates, rattle small, size small. (65.). Ground Rattlesnake (*Sistrurus miliarius*) (Brunswick, Carteret, Cumberland, New Hanover).
   Top of head covered with small scales, size large, rattle large ... 4
4. Markings on back in form of diamond shaped blotches. (66.). Diamond Rattlesnake (*Crotalus adamanteus*) Carteret, Craven, Pender, Onslow, Brunswick).
   Markings on back in form of cross-bands, or the animal sometimes entirely black above. (67.). Banded Rattlesnake (*Crotalus horridus*) (E, M, also McDowell, Orange, Alexander and Polk Counties).
5. Top of head blackish brown, color dark. (68.). Cottonmouth Mocassin (*Agkistrodon piscivorus*) (E.).
   Top of head reddish, color paler. (69.). Copperhead Mocassin, "Highland Mocassin" (*Agkistrodon mokasen*) (SW.).
6. Upper jaw with a short permanently erect poison fang on each side in front, body marked with complete alternating rings of black, red and yellow, every alternate ring being yellow. (70.). Coral Snake (*Micrurus fulvius*) (Hoke, Moore, Onslow, New Hanover).
   Upper jaw without poison fangs in front. (If the body is ringed with red, black and yellow, every alternate ring is black) 7
7. Back and sides practically uniform in color, neither being either striped, banded, or blotched 8
   Back or sides or both with distinct markings 20
8. Upper parts green in color 9
   Upper parts not green 10
9. Scales smooth. (71.). Northern Green Snake (*Liopeltis vernalis* ("NC.").
   Scales keeled. (72.). Southern Green Snake (*Opheodrys aestivus*) (E, C.).

10. Upper parts black..... 11
Upper parts not black..... 15
11. Snout recurved and keeled, all the scales keeled. (73.). Spreading Adder (*Heterodon contortrix*) black variety. (Wake).
Snout not recurved or keeled, at least some of the lateral rows of scales not keeled..... 12
12. Anal plate entire, all scales smooth, chin and throat red. Indigo Snake (*Drymarchon corais couperi*) (SC.).
Anal plate divided..... 13
13. Belly red with black cross bars. (74.). Swamp Black Snake (*Seminatrix pygaea*) (Carteret).
Belly not red and without black cross-bars..... 14
14. Underparts all black except the chin and throat. (75.). Black Snake (*Coluber constrictor*) (SW.).
The front third of the under-parts mostly white. (76.). Black Chicken Snake (*Elaphe obsoleta*) (SW.).
15. Scales keeled..... 16
Scales smooth..... 17
16. Size small, never reaching 12 inches in length. (77.). Ground Snake (*Potamophis striatulus*) (E, also Orange).
Size large, never less than 18 inches long, under-parts coppery red. (78.). Copperbelly (*Natrix erythrogastra*) (Wake, Craven, Bladen, Lenoir).
17. Size large, head and front part of body blackish. (79.). Coachwhip (*Coluber flagellum*) (E, south of Pamlico Sound).
Size small, length less than 15 inches, head and front part of body not blackish..... 18
18. Under parts reddish. (80.). Worm Snake (*Carphophis amoenus*) (SW.).
Under parts whitish or yellowish..... 19
19. Reddish brown, yellowish white below, top of head darker than back. (81.). Brown-headed Snake (*Leimadophis flavilatus*) (Carteret, Bladen).
Grayish brown above, often with small black dots, head concolorous with back. (82.). Valeria's Snake (*Virginiae valeriae*) (Wake, Iredell, Cherokee, Orange, New Hanover).
20. Markings confined to red and black blotches on the sides, underparts red, size large, scales smooth. (83.). Horn Snake (*Farancia abacura*) (E.).
With some markings other than on sides..... 21

21. Upper parts unmarked except for one or more crossbands on the neck, length 18 inches or less 22
Body spotted or striped above 25
22. Under-parts yellow, cross-band on neck yellow 23
Under parts not yellow, cross-band not yellow 24
23. Yellow cross-band on neck usually interrupted in middle, under-parts with a median row of black spots down most of their length. (84.). Ring-necked Snake (*Diadophis punctatus*) (E, C.).
Yellow cross-band on neck not interrupted, under-parts with fewer black spots, often unspotted. (85.). Northern Ring-necked Snake (*Diadophis punctatus edwardsi*) (M.).
24. A black cross-band on neck preceded by a white one, top of head usually dark. (86.). Crowned Tantilla (*Tantilla coronata*) (Wake, Moore, Duplin).
A pale or white cross-band across the back of head, under-parts reddish. (77.). Ground Snake (*Potamophis striatulus*), some young specimens.
25. Body striped lengthwise 26
Body not striped 33
26. Scales keeled 27
Scales, or at least most of the lower rows, smooth 32
27. Upper parts with black stripes on a brown ground 28
Upper parts with pale stripes 29
28. Three black stripes on back, a yellow band along sides, belly with dark stripes. (87.). Queen Snake (*Natrix septemvittata*) (C, M.).
Two black stripes on back, belly with dark spots, no yellow band along sides. Stiff Snake (*Natrix rigida*) (SC.).
29. Size small, under 18 inches long when adult, no side stripes but only one down middle of back 30
Size larger, adults over 18 inches long, a median stripe and one down each side 31
30. Under-parts red, three pale spots on nape. (88.). Red-bellied Snake (*Storeria occipitomaculata*) (SW.).
Under-parts whitish, no pale spots on nape. (89.). DeKay's Snake (*Storeria dekayi*) (Wake, Lenoir, Orange, New Hanover, and Swain).
31. Side stripes on third and fourth rows of scales counting from belly, no square black spots between median and side stripes. (90.). Ribbon Snake (*Thamnophis saurita*) (SW.).

Side stripes on second and third rows of scales, square black spots between median and lateral stripes. (91.). Garter Snake (*Thamnophis sirtalis*) (SW.).

32. Three red stripes on a black ground, under-parts red, spotted with black. (92.). Rainbow Snake (*Abastor erythrogrammus*) (E.).

Four dark stripes on a yellowish ground, under-parts varying from yellowish to blackish. (93.). Striped Chicken Snake (*Elaphe quadrivittata*) (E.).

33. Body above with crossbands of red, black, and yellow (or white), every alternate band being black..... 34

Body marked otherwise..... 36

34. Under-parts wholly white, unblotched. (94.). Scarlet Snake (*Cemophora coccinea*) (Wake, Beaufort, New Hanover, Moore and Duplin).

Under-parts marked with red and black..... 35

35. The red rings encircling the body without interruption. (95.). Red King Snake (*Lampropeltis elapsoides*) (Wake, Orange, Rutherford, Bertie, and Hyde).

The red bands interrupted on the belly by black. (96.). Virginia Red King Snake (*Lampropeltis elapsoides virginianus*) (Wake).

36. Scales all smooth..... 37

Scales keeled..... 44

37. Black with narrow white cross-bars forking on the sides. (97.). King Snake (*Lampropeltis getulus*) (SW.).

Marked otherwise..... 38

38. Under-parts with squarish black spots..... 39

Under-parts not with squarish black spots..... 40

39. Head large, broader than the neck, anal plate divided. (98.). Corn Snake (*Elaphe guttata*) (E.).

Head small, not broader than neck, anal plate undivided. (99.). Milk Snake (*Lampropeltis triangulum*) (M, also Lenoir).

40. Head large, broader than neck, anal plate divided..... 41

Head small, not broader than neck, anal plate undivided. (100.). Brown King Snake (*Lampropeltis rhombomaculatus*) (Wake, Orange, Beaufort, Forsyth).

41. Scales in 25 or 27 rows..... 42

Scales in 19 rows..... 43

42. General color yellower, under-parts yellowish. (93.). Striped Chicken Snake (young).

General color grayer, under-parts whitish in front, blackish behind. (101.). Spotted Chicken Snake (*Elaphe obsoleta confinis*) (Lenoir, Northampton. Our records are open to doubt, as the young of the Black Chicken Snake is indistinguishable from it, and I have never personally seen one from North Carolina).

43. Upper lip plates 7 on each side. (75.). Black Snake, young.
Upper lip plates 8 on each side. (79.). Coachwhip, young.

44. Snout recurved and keeled..... 45
Snout rounded, neither recurved nor keeled..... 46

45. Small plate just behind the snout plate with several small scales around or next to it, snout more strongly recurved and keeled, color usually pale. (102.). Hog-nosed Snake (*Heterodon simus*) (E.).
Said plate without any small scales around it, snout less strongly keeled and recurved, color very variable but often much darker than *simus* ever is. (73.). Spreading Adder (*Heterodon contortrix*) (SW.).

46. Anal plate not divided, ground color whitish with dark markings, (104.). Pine Snake (*Pityophis melanoleucus*) (Moore, New Hanover, Swain).
Anal plate divided, ground color not whitish..... 47

47. Only the middle rows of scales keeled, those on side smooth, spotted young of the Chicken Snakes (see couplet 42).
All the scales keeled, water snakes..... 48

48. With scales in from 27 to 33 rows, spots on back alternating with but separated from spots on sides. (105.). Water Pilot, Pied Water Snake (*Natrix taxispilota*) (E.).
With scales in from 21 to 25 rows..... 49

49. With a light line obliquely from eye to corner of mouth, cross-bands on back mainly extending on to sides without alternating spots. (106.). Southern Water Snake (*Natrix fasciata*) (E.).
Without a light line from eye to corner of mouth, spots on back alternating with spots on sides at least posteriorly..... 50

50. Front part of body with dark cross-bars only and not with alternating median and lateral spots, belly with numerous black-edged half circles. (107.). Northern Water Snake (*Natrix sipedon*) (C, M.).
Alternating median and lateral spots extending about to head,

under-parts unmarked or with dusky mottlings. (78.). Copperbelly (*Natrix erythrogastra*) (E.), young, for adult see couplet 16.

GROUP VI. THE TURTLES

1. Limbs flattened, paddle like, not capable of movement at wrist or ankle joints: fingers and toes flattened, elongate, immovable, bound together by the skin. Sea Turtles..... 2
   Limbs not paddle-like, capable of movement at wrist and ankle. 6
2. Head and shell covered with a black leathery skin and without distinct plates, shell with longitudinal ridges separated by deep grooves. (107.). Leather-back Turtle (*Dermochelys coricea*) (Occasional off the coast).
   Head and shell covered with distinct horny plates and the latter without longitudinal ridges..... 3
3. Scales around large plate on top of head 13 or more, costal plates five on each side..... 4
   Scales around said plate 7, costal plates four..... 5
4. Crushing surfaces of jaws without ridges, plates on under side of bridge normally three. (108.). Loggerhead Sea Turtle (*Caretta caretta*) (Off the coast in summer, breeds on the Banks).
   Crushing surface of jaws with ridges, plates on under side of bridge normally four. (109.). Kemp's Loggerhead, Bastard Turtle (*Caretta kempi*) (Off the coast in summer, breeds elsewhere in winter).
5. Carapace with smooth, not overlapping plates, nails on front limbs one each. (110.). Green Sea Turtle (*Chelonia mydas*) (Occasional off the coast).
   Carapace with loosely overlapping plates, nails on front limbs two each. Tortoise-shell Turtle, Hawks-bill Turtle (*Eretmochelys imbricata*) (Warm seas, has been recorded apparently erroneously from North Carolina waters).
6. Shell covered with horny plates..... 7
   Shell covered with a leathery skin without plates, flattened and orbicular..... 31
7. Plastron narrow, cross-shaped, the plates of its central portion nine..... 8
   Plates of lower shell or plastron more than nine..... 9
8. Under surface of tail with small scales, shell with three strong keels at all ages. Alligator Snapper (*Macrochelys temmincki*) (Ga.).

Under surface of tail with rather large plates, shell without keels in adult. (111.). Snapping Turtle (*Chelydra serpentina*) (SW.).

9. Plastron with ten or eleven plates, front and hind portion hinged on middle part and capable of partially closing shell.. 10
Plastron with twelve plates..... 13

10. Plastron comparatively small, hind portion capable of little movement, the second pair of plates from in front each side four sided, the sides subequal..... 11
Plastron larger, hind portion more movable, each of second pair of plastral plates triangular or nearly so, the inner side of each very short or wanting. (112.). Mud Turtle (*Kinosternon subrubrum*) (E, C.).

11. Plastron strongly keeled at all ages, head without yellow stripes. 12
Plastron keeled only in the young, head with yellow stripes. (113.). Musk Turtle (*Sternotherus odoratus*) (E, C.).

12. Shell with three evident keels. Three-keeled Musk Turtle (*Sternotherus minor*) (Ga., Eastern Tenn.).
Shell evenly sloping on the sides without side keels. Keeled Musk Turtle (*Sternotherus carinatus*) (West Tennessee).

13. Plastron of two pieces, both movable on a transverse hinge and joined to the carapace at the sides by a cartilaginous suture.. 14
Plastron in one piece, immovable, joined to the carapace at the sides by a bony bridge..... 15

14. Claws on hind feet three each. Three-toed Box Turtle (*Terrapene carolina triunguis*) (SC.).
Claws on hind feet four each. (114.). Box Turtle, "Highland Terrapin" (*Terrapene carolina carolina*) (E, C, MV.).

15. Limbs thick and club-shaped, hind limbs the smallest, shell with concentric striae on the plates but not keeled, marginal plates twelve, there being a single undivided plate in front and another behind over the tail, terrestrial and burrowing in habits. Gopher Turtle (*Gopherus polyphemus*) (SC.).
Limbs not club-shaped, hind limbs usually the largest, a pair of plates just above the tail making the marginals including the single undivided nuchal in front normally thirteen..... 16

16. Masticating surface of jaws narrow..... 17
Masticating surface of jaws broad..... 19

17. Shell keeled and with concentric striae on the plates giving the shell a lumpy appearance, terrestrial. Wood Terrapin (*Clemmys insculptus*) (Va.).
Shell smooth without striae or keel, head without narrow stripes. 18

18. Head and shell with round yellow spots. (115.). Speckled Terrapin (*Clemmys guttatus*) (E.).
    Head and shell without round yellow spots, a yellow patch on each side of neck. (116.). Muhlenberg's Terrapin (*Clemmys muhlenbergi*) (M.).
19. Shell smooth without wrinkles or keel..... 20
    Shell keeled or with wrinkles on the plates or both..... 21
20. Costal plates in line with the vertebrals so that the plates are in straight series across the shell. (117.). Painted Terrapin (*Chrysemys picta*) (E, C.).
    Costal plates alternating with vertebrals so that the plates are not in transverse rows. Western Painted Turtle (*Chrysemys marginata*) (Tennessee).
21. Head and neck, when extended, about two-thirds length of shell, shell long and narrow, finely wrinkled all over, with a reticulated pattern of narrow yellow lines in large mesh. (118.). Chicken Turtle (*Deirochelys reticularia*) (New Hanover, Cumberland, Carteret).
    Head and neck not more than half length of shell..... 22
22. Masticating surface of jaws with longitudinal ridge down middle, species of large size, the carapace usually variegated.... 23
    Masticating surface without longitudinal ridge..... 28
23. Edge of one or both jaws serrated..... 24
    Both jaws with smooth edges, and upper jaw with a notch at the symphysis..... 26
24. Both jaws serrated with a notch at symphysis of upper jaw and a strong tooth or cusp on each side of it, carapace marked with red, plastron red. (119.). Red-bellied Terrapin (*Pseudemys rubriventris*) (Lenoir, New Hanover).
    Only lower jaw serrated, upper jaw without notch or cusps at symphysis, plastron yellow..... 25
25. Shell comparatively short and high, markings on costal plates mainly transverse. (120.). Florida Terrapin (*Pseudemys floridanus*) (Johnston, Craven).
    Shell comparatively long and flat, markings on costal plates confused or reticulated. (121.). River Terrapin (*Pseudemys concinna*) (Wake, Bladen, Columbus, Edgecombe, Orange).
26. Shell with an evident keel at all ages, an upright yellow bar behind eye, black markings of plastron confined usually to

a round black spot on each of the two anterior plates, sometimes with a black spot on each of all or nearly all the plates. (122.). Yellow-bellied Terrapin (*Pseudemys scripta*) (Wake, Guilford, Carteret, Craven, Bladen, Scotland, New Hanover, Columbus, Sampson).

Shell not keeled except in the very young..... 27

27. An oval red spot on neck behind eye and conspicuous yellow lines on head, neck, limbs and shell. Red-necked Terrapin (*Pseudemys elegans*) (Tenn.).

Shell black above, usually without markings which are also largely or wholly wanting on head, neck and limbs. (123.). Troost's Terrapin (*Pseudemys troosti*) (Wake).

28. Shell usually with concentric striae on the plates, salt-marsh species, the head without yellow stripes..... 29

Shell without concentric striae, freshwater species with narrow yellow stripes on head and neck..... 30

29. Head large to medium, sides of carapace sub-parallel, usually without pale concentric markings on the carapace. (124.). Southern Diamond-back Terrapin (*Malaclemmys centrata*) (Salt-marshes, south of Cape Hatteras).

Head medium to small, sides of carapace widest posteriorly, shell usually with pale concentric markings. (125.). Northern Diamond-back Terrapin (*Malaclemmys centrata concentrica*) (Saltmarshes, north of Cape Hatteras).

30. Keel of shell even, not tuberculate, a more or less triangular yellow mark behind eye. Map Terrapin (*Graptemys geographicus*) (Va.).

Keel of shell higher, tuberculate at posterior ends of each plate, an L-shaped yellow mark behind each eye. LeSueur's Terrapin (*Graptemys pseudogeographicus*) (Va.).

31. Shell with tubercles in front in adult..... 32

Shell without tubercles in front in adult. Brown-Soft-shelled Turtle (*Trionyx muticus*) (Tenn.).

32. Two pale bands on head forking a short distance in front of eyes. (126.). Southern Soft-shelled Turtle (*Trionyx ferox*) (Wake County, once, possibly an introduced specimen—South Carolina).

Two pale bands on head forking at base of proboscis. Spiny Soft-shelled Turtle (*Trionyx spiniferus*) (Tenn.).

This makes a total of 127 forms recorded so far from North Carolina divided as follows:

Salamanders	35,	added since 1907, 11;	eliminated, 3
Frogs and toads	22,	added since 1907, 6;	eliminated, 1
Crocodilians	1,	added since 1907, 0;	eliminated, 0
Lizards	7,	added since 1907, 1;	eliminated, 0
Snakes	42,	added since 1907, 9;	eliminated, 0
Turtles	20,	added since 1915, 2;	eliminated, 1
Totals	127	29	5

DIVISION OF ENTOMOLOGY,
N. C. DEPT. OF AGRICULTURE,
RALEIGH, N. C.

SOME PHASES OF THE EMBRYOLOGY OF THE CARNATION MITE

By O. C. Bradbury

Plates 7–9

In this paper we wish to present certain phases of a peculiar type of development restricted to mites of the family, *Tarsonemidae*, to which the carnation mite belongs. We will present only the external phases of the development on account of lack of space and because they are so outstanding that they distinguish this type of development from all others.

The mite under discussion is called the carnation mite because it is often found in the buds of carnations. The fungus, *Sporotrichum poae* Peck, is usually found in the buds along with the mites and causes bud rot whenever present. Apparently the spores of the fungus are carried into the buds on the bodies of the mites.

The carnation mite, *Pediculopsis graminum* Reuter, as well as other members of the family, *Tarsonemidae*, reproduces differently from other mites. In most mites the development takes place from an egg outside of the mother's body. In the case of the carnation mite the young go through their entire development within the body of the mother. As a consequence the abdomen of the mother begins to enlarge soon after fertilization occurs to accomodate the growing embryos (about 60 in number). This enlargement continues until the mother's abdomen is 60 to 100 times its original size. Embryos in all stages of development may be found in the maternal uterus, the youngest being situated most anteriorly. The young are born sexually mature and often mate on the outside of the mother's abdomen. In working out this problem serial cross sections were made through the abdomens of several gravid females, thereby obtaining numerous sections through several hundred embryos.

Several distinct stages may be readily distinguished in the development of most mites such as the larval, deutovum and nymphal stages. In the embryology of the carnation mite such stages can not be distinguished, the development consisting of one continuous and gradual process. The eggs of the carnation mite gain their vitellus before leaving the ovary. They then pass down into the dilated part of the oviduct

where fertilization probably occurs. Later this dilation of the oviduct takes on the function of a uterus where development of the embryos occurs. Cleavage of the egg is of an unusual type, called inter-leukocytal. The centrally located nucleus and cytoplasm divide into two, four, eight and more cells without the vitellus being included in the process of division (figs. 4–8). The cells as they divide remain suspended in the vitellus and absorb nutrition as required. As the cells become more numerous they gradually migrate through the vitellus to the surface of the egg, forming a single layer of cells, the blastoderm (fig. 9). The surface of the egg does not enter into the cleavage process and is not changed by it. Hence the cell wall of the egg becomes the blastodermal membrane. The blastula stage thus formed is filled with vitellus and is practically the same size as the egg before cleavage (fig. 9). A typical gastrula stage is not formed, the endodermal and mesodermal layers being produced from the blastodermal (ectodermal ?) layer by delamination.

As development proceeds the blastoderm becomes thicker, particularly on the ventral side (fig. 10). At the same time the stomodeum (the primitive mouth) and the proctodeum (the primitive anus) are formed (fig. 11). The stomodeum is situated somewhat ventrally and the proctodeum dorsally. Along with these developments a longitudinal ventro-median groove appears (fig. 12). A little later on either side of this groove six rounded elevations are produced from which the first set of appendages develop. This set of appendages corresponds to the larval set of appendages in other mites. The appendages consist of four pairs of walking legs, one pair of chelicerae and one pair of pedipalpi, the latter two pairs forming the mouth parts. Constrictions appear on the four pairs of legs which indicate the beginning of segmentation (figs. 14, 15 and 16).

Following the development of the first set of appendages up to the point indicated, there occurs a regression of them. The regression continues until the appendages have practically disappeared, leaving the cuticle (the original egg membrane) separated from the ventral part of the embryo (fig. 18 and 19). Immediately following the regression of the first set of appendages, a second set begins to develop from the points of origin of the first set (fig. 21). This second set of appendages corresponds to the appendages of the nymphal stage in other mites. As the second set of appendages develops, a new cuticular envelope is also formed. Hence with the development of the second set of appendages the embryo is surrounded by two cuticular envelopes, the first one (the original egg membrane) becoming entirely separated

from the embryo's body while the second remains in contact with it. This stage corresponds in part to the deutovum stage in other mites. The second set of appendages may be distinguished from the first set in that the fourth leg differentiates more rapidly than the others in the second set, while in the first set it is the first leg that is longer than the others (fig. 22).

The second set of appendages continues to develop until they are fully differentiated. At the same time the embryo gradually takes on the adult form. Even in the adult stage the mite is surrounded by the original egg membrane (fig. 23–26). Indeed mites are sometimes born entirely enclosed in this membrane. Of course the development of the internal organs occurs at the same time that the mite is taking on the adult shape.

To summarize: First, cleavage in this mite is a modification of the superficial type peculiar to insects and is given the name, inter-leukocytal. Second, the entire development is very much condensed so that it is impossible to distinguish stages which ordinarily occur in other mites. Third, the development is entirely completed within the maternal uterus, and hence is an example of the most complete intrauterine development known.

WAKE FOREST COLLEGE,
WAKE FOREST, N. C.

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EXPLANATION OF PLATES

LIST OF ABBREVIATIONS USED IN PLATES

ab.—abdomen.
ap.′—first set of appendages.
ap.″—second set of appendages.
bl.—blastoderm.
ch.—chelicerae.
cl.—clavate organ.
cr.—crystal of urea.
cut.′—first cuticular envelope.
cut.″—second cuticular envelope.
c.w.—cell wall.
dil.—dilation of oviduct.
ect.—ectoderm.
ex.—wall of excretory organ.
ex.o.—excretory organ.
gen.—genital organ.
int.—intestine.
L.′—first leg.
L.″—second leg.
L.‴=third leg.
L.⁗—fourth leg.
m.c.—migratory cell.
nu.—nucleus.
ov.—ovary.
ovi.—oviduct.
ov.c.—ovarian cell.
ov.w.—ovary, wall.
ped.—pedipalpus.
pr.—proctodeum.
pro.—protoplasm.
r.—rostrum.
seg.—segmentation.
st.—stomodeum.
th.—thorax.
v.gr.—ventral groove.
vit.—vitellus.

PLATE 7

Fig. 1. Cross section of portion of wall of ovary; the cuboidal ovarian cells from which the eggs develop.
Fig. 2. Cross section of the wall of the ovary; the young eggs developing.
Fig. 3. Longitudinal section of a full grown egg just before segmentation of the protoplasm, vitellus beginning to form into globules.
Fig. 4. Longitudinal section of egg; protoplasm divided into two masses.
Fig. 5. Longitudinal section of egg, four cell stage.
Fig. 6. Longitudinal section of egg, eight cell stage.
Fig. 7. Longitudinal section of egg, 16 cell stage. Cells organized here.
Fig. 8. Longitudinal section of egg, beginning of formation of blastoderm.
Fig. 9. Longitudinal section of embryo, blastula stage.

PLATE 8

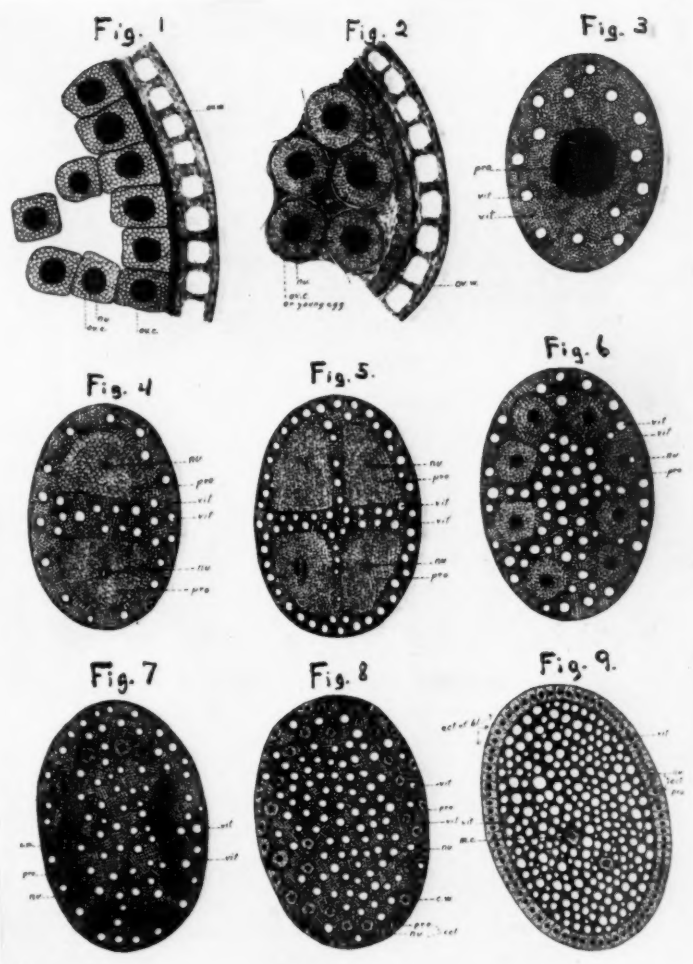
Fig. 10. Longitudinal section of embryo, ventral thickening of blastoderm.
Fig. 11. Longitudinal section of embryo ectodermal invaginations forming stomodeum and proctodeum.
Fig. 12. Cross section of embryo, formation of ventro-median groove.
Fig. 13. Cross section, appearance of first set of appendages.
Fig. 14. Longitudinal section, beginning of first set of appendages.
Fig. 15. Cross section, constrictions marking beginning of segmentation.
Fig. 16. Longitudinal section, differentiation of pedipalpi and first pair of legs.
Fig. 17. Cross section, beginning of regressive changes in appendages, i.e., disappearance of segmentation.
Fig. 18. Cross section, regressive changes completed in the appendages.

PLATE 9

Fig. 19. Longitudinal section, regressive changes in appendages completed.
Fig. 20. (a) Crystals of urea, (b) Cross section of portion of wall of excretory organ.
Fig. 21. Cross section, appearance of second set of appendages and second cuticular envelope.
Fig. 22. Longitudinal section, appendages developing, fourth leg differentiated.
Fig. 23. Side view of "nymphal" stage showing shape and body divisions with definitely formed legs.
Fig. 24. Dorsal view of same stage as in figure 23 showing clavate organ.
Fig. 25. Dorsal view of female showing final shape of body.
Fig. 26. Side view of female showing final shape of body dorso-ventrally.

Note: Figures 23, 24, 25 and 26 show the mite still surrounded by the original egg membrane (the first cuticular envelope).

PLATE 7



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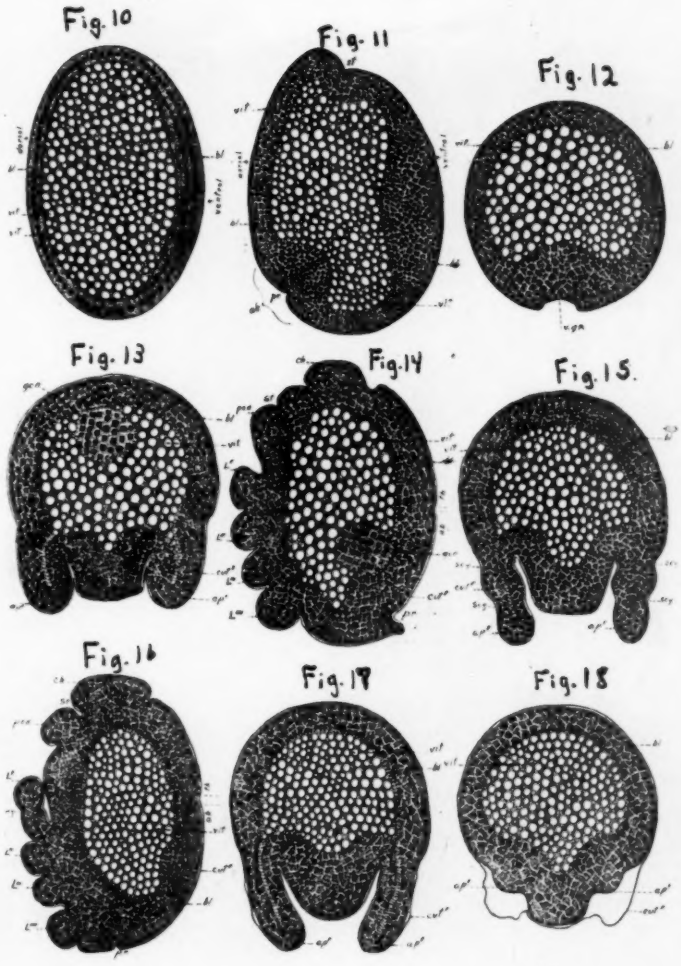
Fig. 10
Fig. 11
Fig. 12
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Fig. 15.
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Fig. 17
Fig. 18

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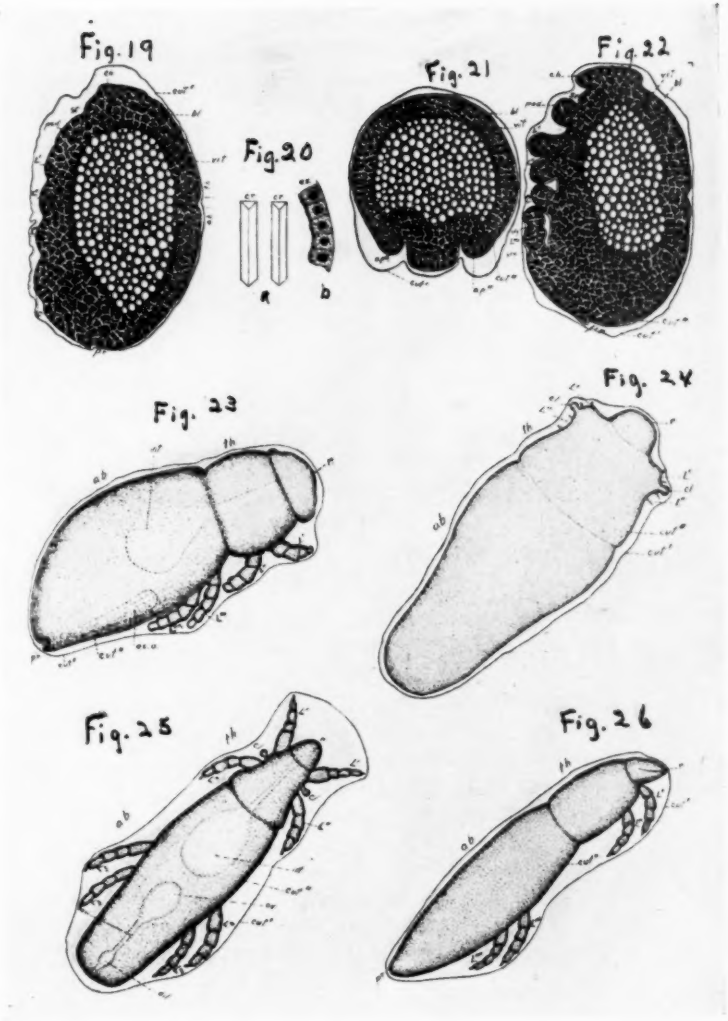
PLATE 9



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THE RELATION OF TEMPERATURE, LIGHT AND HUMIDITY TO THE BEHAVIOR AND LONGEVITY OF A JOINT WORM PARASITE (EURYTOMA SP.)

By C. H. Brannon

Introduction

The insect under discussion is a parasite upon *Harmolita tritici* (Fitch), which is a very destructive enemy of wheat in certain sections east of the Mississippi River (fig. 1) (small area west of Mississippi River excepted).

Harmolita tritici would probably be our worst insect enemy of wheat if it were not for the control of this pest by *Eurytoma* sp. and other important hymenopterous parasites. Present systems of crop rotation are very favorable for the development of *Harmolita tritici* and artificial control has proved of no practical value.[1]

Life History of the Host

Harmolita tritici passes the winter mostly as pupae. Most of the larvae pupate in early fall and the rest pupate in early spring. Adults emerge in May and begin oviposition just before the wheat plants head out. Eggs are usually deposited just above the second or third joint. Dozens of eggs are deposited above a single joint. As these eggs hatch in the wall of the wheat stem, the young larvae in feeding disarrange the fibro-vascular bundles and greatly weaken the wheat stem. This results in fallen wheat, short, light heads and stunted growth.

Often the galls produced by the larvae feeding in the walls of the wheat plant can be easily detected by the eye, but infestation can be surely detected by pressing the wheat stem (just above the second or third joint) between the thumb and forefinger.

Only one generation appears each year. The eggs hatch in about

[1] The writer has no access to the notes he originally made in connection with the investigations noted herein. Hence it is impossible to include detailed data, such as tables and figures in connection with this paper. The work was done while the writer was employed by the United States Department of Agriculture.

ten days and the larvae mature in about three weeks. Males occur normally but the species will breed parthenogenetically.

IMPORTANCE OF THE PARASITE (EURYTOMA SP.)

It would be difficult to disk or plow under wheat stubble to destroy *Harmolita tritici* because of the valuable forage crop that follows wheat in the East. Hence the importance of the hymenopterous parasites (which are the only known means of control) becomes at once apparent.

The writer has seen fields of wheat infested with *Harmolita tritici*

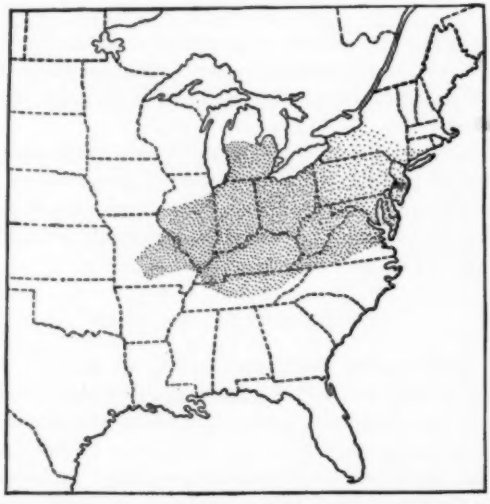

Fig. 1. General area of infestation of *Harmolita tritici*

to the extent of 75% and over, and was often embarrassed in not being able to inform farmers of a satisfactory means of control.

Fortunately the parasites have usually kept the joint worm under control, but occasionally the host increases at an enormous rate and the parasites are unable to cope with the situation. Many fallen and lodged plants result. When the binder is used in harvest, it completely passes over these fallen plants and in a heavily infested field the plants that remain headed in the field can be seen everywhere. Many plants that are shocked yield greatly dwarfed heads producing short yield.

LIFE HISTORY OF EURYTOMA SP.

The life history of this parasite is practically the same as its host. But it usually emerges earlier than *Harmolita tritici*. Now in studying *Harmolita tritici* under artificial conditions parasites were to be used in connection with the study. In attempting to study this important parasite under artificial environment a tremendous barrier as suggested above was encountered.

Eurytoma emerges anywhere from several days to several weeks, before *Harmolita tritici* and must be kept alive and in good condition until *Harmolita tritici* has oviposited and the resultant host is ready to be parasitized by *Eurytoma* sp.

METHODS USED

Various methods used to keep these parasites alive until they could be used proved unsuccessful. It is not known what the parasites feed upon in the field, but we believe they feed on nectar of flowers until the host is sufficiently developed for them to oviposit.

Therefore, natural environment was duplicated as nearly as possible, keeping in mind that the insects must be collected for use. In working out this problem the major discussion of this paper is approached.

A muslin cloth cage was first used in an attempt to keep the parasites alive. Heretofore, practically all the parasites were dead before ready for use on *Harmolita tritici* as host, when kept in small glass vials with cotton plugs. A frame 1 yd. x 2 yds. was built and muslin stretched over it. This was placed over wheat plants mixed with various grasses and weeds. A number of *Eurytoma* were liberated in the cage. Several days later the cage was examined and several *Eurytoma* were noted under the top side. Two days later the cage was examined and four or five *Eurytoma* were noticed on the side and top of the cage. Two specimens were seen on the wheat plants. A week later several specimens were noticed. Ten days later I attempted to collect a number of *Eurytoma* from the cage for oviposition in the *Harmolita tritici* cages. It became evident that very few of the specimens could be found. If they were alive, it was physically impossible to find them. This cage while more nearly duplicating field conditions did not afford means for collecting a large number of the specimens when ready for use. Let me state that we could obtain only a limited number of the parasites from the host material. If we had thousands of specimens to liberate in a big cage, a good number could possibly be collected for use, but this method proved too impracticable.

Glass cylinder cages were next used. Glass cylinders 12″ x 24″ open at both ends were placed over moist sand in large flower pots. A muslin top was placed over the cylinder to permit normal temperature in the cage. Dilute sugar solution was daubed on the side of the cylinder for food. The cages placed outside in the shade during the day and moved under cover at night to prevent damage by wind and rain. The sand was kept slightly moist and food was supplied each day after washing the side of the cylinder.

The insects were very active in the cage and were noticed to feed and fly around very actively. Several hundred parasites were in the cage. The glass vials containing the galls were examined each day and the parasites removed to the glass cylinder cage as they emerged.

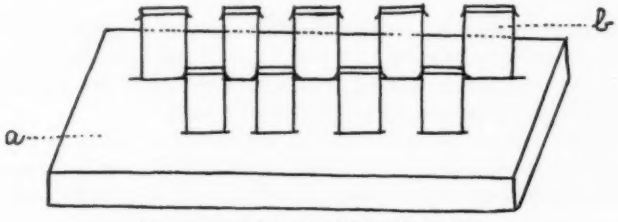

FIG. 2. *a*, plaster cast; *b*, glass vials

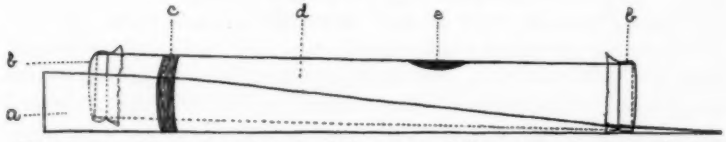

FIG. 3. *a*, stiff paper jacket; *b*, cloth cap; *c*, sticky paper; *d*, glass cylinder; *e*, bees wax patch.

In spite of all that was done this method was absolutely unsuccessful. The parasites died a few days after being put in the cage and it was evident that other methods of keeping these parasites under artificial conditions must be found.

Plaster of paris casts (fig. 2) were made 6″ x 12″. Light wood frames were used, the plaster poured in and the frames destroyed in removing them. One-fourth inch holes were bored in the plaster with brace and bit after the plaster had become hard. Small glass vials, open at each end were used to fit in these holes bored in the plaster. Beeswax patches were placed on the inside of the vials to hold a drop of honey

solution for food. The honey solution was diluted 1 in 3 and boiled each day to destroy fungous or bacterial growth.

About 10 or 15 *Eurytoma* sp. were placed in each of the vials and the vials were fitted into the plaster cast. One cast of tubes or vials was placed in the laboratory cellar, one placed outside in the shade and one was left in the laboratory to determine if possible what environmental conditions would be best for keeping the parasites alive. I failed to state that cheesecloth tops were placed on the glass vials, held in place by a rubber band.

Dilute sugar solution was placed in several of the vials but the insects seemed to prefer honey solution. Great difficulty was experienced in feeding the insects each day. A long glass stirring rod was used to place the honey solution on the beeswax patch, after the patch had been cleaned with alcohol. When the vials were lifted out of the plaster cast for feeding operations some of the *Eurytoma* escaped and some were entangled in the honey solution. Others had dropped to the bottom of the cast and were crushed when the vial was put back in place. The insects were very active.

Many of the *Eurytoma* died, especially in the vials placed outside and in the laboratory. The parasites placed in the cellar did very well but feeding was exceedingly difficult and the whole method of procedure seemed too difficult and clumsy.

The parasites in the cellar (which was under ground, cool, dark, and damp) were very inactive except when they were brought out to be placed in clean vials. The warm air stimulated them, while the parasites outside were active practically all the time except at night. No artificial moisture was added except the food material.

SUCCESSFUL METHODS

The vials and cylinders used as cages, heretofore, experimented with, were placed in a vertical position. This made feeding difficult in the case of the small vials and in some instances caused the food materials to run down the side of the cage, entangling the parasites and often causing them to be killed.

It was decided next to try a glass cylinder (fig. 3) not as big as the flower pot cage, so that it might be easily moved from place to place. Also a larger cylinder than the small vials was thought to be much more satisfactory.

Cylinders 2″ x 6″ open at both ends were used. Cheese cloth was placed over one end of the tube, held in place by a rubber band. The

cylinders were placed horizontally in a box and prevented from rolling by a stiff paper jacket fitted to each of them. Bees wax was used as a food patch after trying paraffin patches which were much less satisfactory, not holding the food as did the bees wax. The melted bees wax was placed about one-third the length of the cylinder. In placing the honey solution on the bees wax patch, the cylinder was turned until the patch was at the bottom. A long glass stirring rod was used to place the honey solution on the patch. The cylinder was then turned in its jacket until the patch was directly above. The drop of honey solution would hang from the bees wax without running or dropping.

Between 500 and 1000 *Eurytoma* were released in six of these cylinder cages. The insects were noticed to feed, copulate and fly around very actively. Some would fall from the topside of the cylinder and fly off again. Others seemed stunned by the fall and would appear dead in a short time.

It appeared that while the insects were active under artificial conditions as described they died very fast. In the small glass vial it was noticed that the insects placed in the cellar remained inactive and lived much longer. Hence it was decided to place two of the cylinders in the laboratory cellar, two out in the open in the shade and leave two in the laboratory. This would certainly give data relative to the best conditions under which the insects could be kept alive and in good shape under artificial environment.

The insects in the cylinders placed outside were noticed to be very active. They flew around frantically and crawled very fast, some were feeding, others were noticed in coitu. A few dead insects were noticed in the bottom of the cylinder a short time after the cylinder had been placed outside. That afternoon many more of the parasites were noticed dead.

Food was changed each day and the insects were placed in fresh cylinders three times a week. No artificial moisture was supplied other than food. Cheese cloth was placed over each end of the cylinder so that air could readily pass through the cylinders.

The *Eurytoma* left in the two cylinders in the laboratory were observed at length. They were moderately active. A few were noticed dead in the bottom of the cylinder. Some were feeding and copulation was noticed. They were not as active as the *Eurytoma* outside and did not die as fast.

Food was changed each day and the insects put in fresh cylinders three times a week.

The temperature inside the laboratory averaged 75° to 80°F. in the day and 65° to 70°F. at night. The temperature outside in the shade was 5° to 10°F. higher than the temperature in the laboratory.

The cylinders which were placed outside and in the laboratory obviously did not furnish conditions best for keeping the insects.

The cylinders in the cellar were constantly observed and the temperature, darkness and humid air of the laboratory cellar were found to be ideal for keeping *Eurytoma* (and Hymenoptera in general, it is believed) for an indefinite length of time.

The laboratory cellar is below the surface of the soil. It has a wooden ceiling, concrete floor and cemented rock sides. It affords ample room to stand without scraping the ceiling. The cellar was 15′ x 25′ x 8′ with steps leading up to the floor above, and electric lights were used for light. The cellar is very damp, cool and dark. The temperature remains constantly at 50°F. night and day regardless of the temperature outside. The cellar is totally dark. There is not a ray of light entering the room except when the door is left open or the lights turned on.

The two cylinders were placed in an open box and placed on a box as a rest. It became at once apparent that the insects which were very active in the warm air and light, immediately became inactive when placed in the cool dark damp cellar.

The experiments with the other cylinders seemed to indicate that the insects should be kept inactive, as the more active they were the faster they seemed to die. But the question of how long they could be kept in an abnormal state of inactivity under artificial environment, must be determined. What environmental conditions were best and would these conditions affect the vitality of the insects?

The electric light was turned on when the cylinders were placed in the cellar. The insects immediately became very quiet though they did not become entirely inactive. A few crawled around slowly but there was no flying and no copulation was observed. No feeding was observed until an hour later when one insect was observed to feed, but no more feeding was observed. The cylinders were left in the cellar and the light turned off.

About an hour later, the cellar was entered and the light turned on. The insects seemed absolutely quiet, resting on the side of the cylinder. This lasted only a few seconds. As a result of the light being turned on a few of the *Eurytoma* began to move about very slowly. There was no flying. Their movements were very slow, no copulation was noticed. No dead insects were noticed. The light was turned off and the cellar was not entered again until the following day.

The next morning the cellar was entered, the door was immediately closed and no light turned on. A few minutes later a flash light was turned on so that a quick view of the *Eurytoma* could be had before the light had much time to stimulate them into action. The insects were in an absolutely motionless state. They appeared to be dormant in every respect. A few seconds after the flash light had been turned on, the insects were noted to move around slowly. No feeding was noticed, no flying and no copulation. The flash light was turned off for 15 minutes then flashed on suddenly. This revealed the insects to be in a dormant condition and remained in that condition evidently until stimulated by the light. One insect was noticed dead but the others revived when the light was turned on and seemed to be in no way impaired by the cool, damp air of the cellar.

The cylinders were then carried out to the warm air of the room above to observe how rapidly they would become active and to note their general condition. The insects at once showed signs of life and gradually became very active. One or two dead specimens were noticed and removed. After the cylinders had been in the warm air and light about 20 minutes the *Eurytoma* were just as active as if they had never been in the cellar.

These *Eurytoma* were placed in clean cylinders. They were exceedingly active—flying, feeding and copulating and crawling rapidly about the cylinder. The temperature in the laboratory was 70°F. and the room was filled with light.

The insects were then returned to the cellar. Just as soon as the cool, moist air was encountered the insects immediately became inactive. Feeding stopped. Only a few moved slowly about the cylinder. As the cylinder became chilled there was less action. In ten minutes very little action was observed. The light was turned out and the *Eurytoma* left.

The cellar was entered 15 minutes and no light was turned on. The door was closed. A few minutes later the flash light was turned on. The insects appeared to be absolutely motionless.

Only a few *Eurytoma* had died in the cellar. Dozens were dying each day in the other cages but the specimens in the cellar remained in a dormant condition and revived at once when stimulated by warm air and light.

The temperature, humidity and darkness in the cellar of the laboratory seemed to meet all of the requirements for keeping hymenopterous insects in a dormant, healthy, condition for an indefinite period. Will

they continue in good condition as they have started out? It is interesting and of great importance to know how long the *Eurytoma* will live in this dormant state. If this method should prove successful in keeping the insects dormant and alive for any length of time a big problem of the laboratory will have been solved.

Heretofore, conditions in the field were duplicated as nearly as possible, believing that this was the logical approach to the problem. But these experiments indicate that active hymenoptera under artificial conditions are very short lived at best.

The cylinders in the cellar were examined only once a week thereafter, when the insects were placed in fresh cylinders. Practically no dead specimens were found and the insects revived at once when brought in contact with warm air and light.

After a month's time there was no doubt as to the proper procedure and technique for holding these parasites over. The insects remained in splendid condition. A few died from time to time but the majority of the insects seemed to be no worse off from their long story in the cellar.

It was decided to let the insects remain in the fresh air and light for 20 to 30 minutes, when the cylinders were changed so that the insects might feed and generally refresh themselves. Many of the specimens were noted to feed during this time.

CONCLUSION

This method described is indeed very simple but is an excellent method for keeping Hymenoptera in a dormant condition, which is the secret of keeping them alive over any length of time.

The mortality of insects of this nature kept under artificial conditions, increases directly as the activeness of the insects is increased by stimulating forces; as light, heat and humidity.

The insects under discussion were kept over three months in the cellar and at the end of that time were released and flew away seemingly in the best of health and spirits. Their vitality did not seem to be impaired in the least. (Further investigations relative to the vitality of insects kept under these conditions should be executed.) At the time the insects were released there was no host material available, hence no oviposition results could be determined.

This experiment does not simply indicate a method of procedure and technique for keeping insects alive for an extended period under artificial conditions, but also suggests environmental conditions most favorable to longevity in the field.

It is not understood how these parasites can live in the field as long as they do. It is not known what they feed upon, or much about their general actions. However, the writer has observed these little creatures parasitizing *Harmolita tritici* in the field when the temperature was close to 100°F. in the shade. The higher the temperature the more active these parasites becomes in parasitizing their host. If it becomes cloudy and a cool wind comes up, these insects cease their activities at once. Hearty insects such as the Mexican cotton boll weevil (*Anthonomus grandis*) and the plum curculio (*Conotrachelus nenuphar*) cannot stand the severe heat under the full rays of the sun. These parasites (*Eurytoma*) thrive in this direct heat. The Mexican cotton boll weevil and the plum curculio seek refuge from the sun and heat. They hide under foliage and in crevices and remain inactive during the heat of the day. Most of their damage is done in the early morning and late afternoon.

As these parasites (*Eurytoma*) prefer warmer temperature and sun light (and are undoubtedly very active from the time of emergence to the time of oviposition) it is significant to note that under artificial environment they can be kept alive only under diametrically opposite conditions. All efforts to keep *Eurytoma* alive under as near normal conditions as possible (and at the same time collected them with ease) proved fruitless in every case.

When these parasites were kept in a dormant condition in the cellar, they seemed to be in excellent condition for over 100 days, when they were released.

May I again state that the environmental conditions found in the laboratory cellar could not be better. The damp air, the steady 50°F. temperature, and absolute darkness, combine to form an ideal environment for keeping hymenopterous insects in excellent condition for several months.

STATE COLLEGE STATION,
RALEIGH, N. C.

THE DROUGHT OF 1925

By Lee A. Denson

Nearly all of that part of the United States east of the Rocky Mountains, also the North Pacific slope and the extreme southwestern section had less than the normal precipitation in 1925. Only that section from Montana to central California and some small areas in southern Kansas, northern Missouri, southern Iowa, southern Florida and central Maryland to northern New York had more than normal. The whole of the cotton belt and most of the corn and wheat regions were comparatively dry. Deficiency was marked in northern Michigan, portions of Texas, eastern Arkansas, western Tennessee, northern Mississippi, northern Florida to Virginia and on the north Pacific coast. Of all sections the deficiency was greatest in the Carolinas and northern Georgia, and of this section greatest in the mountain region and upper Piedmont. The Coastal Plain of North Carolina and Counties bordering thereon had ample rainfall for the year and growing season, though there were dry periods, threatening at times to become serious, but relieved by timely rains.

By reason of location from sea to the highest mountains in the eastern ranges and with respect to the paths of storms of certain of the larger types North Carolina has ordinarily or normally an abundant rainfall of about 50 inches per year, or to be exact the average for all records to December, 1925, was 49.94 inches. Fortunately for this state distribution is good as a rule throughout the year, the largest monthly amounts coming in July and August when most needed and least in the fall months after the leading crops are practically matured and fair weather is needed for harvesting.

One must remember, however, that 50 inches is not the normal county by county. There are marked variations in the annual amount, more so than in any other state east of the Rocky Mountains. The normal varies from about 43 inches in the north central counties and in the French Broad valley to 55 inches near the coast, 55 to 60 in the larger part of the mountains and about 84 inches in the Highlands and Rock House section in the southern portion of Macon County. Twenty-five years ago it was thought that the normal in the southern portion of

Macon County would run about 60 inches, but more complete records since that time show a normal of 84 inches. In traveling over that section one can easily see the effect of the excessive rainfall in the bare cliffs and washed condition of the soil.

The state average is based on about 85 stations and if the two stations, Highlands and Rock House, covering only a small area are eliminated the state average is reduced more than an inch or from 50 to 49 inches. Another inch could be cut from small areas so that the normal over more than 95 per cent of the State is about 48 inches. These points are mentioned in order to bring to mind the general distribution based on records to date.

It is not the purpose at this time to go into the cause and effect of the drought but merely to point out some of the outstanding features with particular reference to North Carolina.

First then, taking the state and year as a whole the 1925 amount of 37.33 inches breaks all previous records by 5.32 inches. To say that this is a remarkable occurrence puts the matter lightly. A record over a period of 35 or 40 years is rarely broken by as much as an inch. In the previous notably dry year of 1911 the record of 42.65 inches was broken by only 0.62 of an inch.

The second point is that the dry period began in the latter part of January, and if the excess of precipitation in January of more than 2.00 inches is eliminated the deficiency for the remainder of the year is of course increased accordingly. If we now eliminate the Coastal Plain which had ample and more than normal rainfall in some localities, the deficiency is still more marked over the remainder of the state.

There were very dry streaks from Durham to High Point, but the deficiency increased westward with the least rainfall at Asheville, and next to the least at Caroleen, Rutherford County, while the greatest deficiency occurred at Rock House, Macon County, which normally has the heaviest rainfall. The rainfall was far below previous records at all the western stations except Bryson City, the deficiency being greatest in the southern portion of the mountains.

The Asheville record shown here in detail day by day for the year is not only the least of any station in the area affected by the drought but also less than the amount of any of all years of record in this state. The outstanding feature of the Asheville record is not the number of days without any rain, but the remarkably light character of the rainfall and the number of days on which rain actually took place during the drought. A trace or sprinkle or more occurred on 180 days, on 12 days

or more in every month, and on an average of one in every two days during the year. On 67 days of this number only a trace was recorded. The first and only day of the year with an inch was on November 12th. The only other date with three-quarters of an inch was March 18th, and as much as half an inch occurred on six days. The total rainfall in the month of August was 0.22 of an inch and 0.77 in July, or 0.99 in the two months of normally heaviest rainfall.

The rivers and streams heading in the mountains and upper Piedmont were lower than ever known within the recollection of the oldest inhabitants. The drought continued through the entire growing season and the deficiency in rainfall was greatest in July and August, followed or intensified in the latter part of August and in September by the highest temperatures of record in this state. This is another remarkable occurrence. Records heretofore show North Carolina's highest temperatures in July, but this carries the absolute maximum into September. No material relief came until the latter part of September and in October and November. The December rains were light and precipitation since that time has not yet restored streams to normal flow.

The drought began in the central portion of the Gulf States and spread northeastward to southern Virginia. There was in the previous year, 1924, a severe drought in the lower Mississippi Valley and Southwest, gradually spreading into portions of western North Carolina in the fall. This raises the question. Will a drought in one section move to or affect an adjoining section in the following season or year? This is a matter that might well be the subject of investigation, but may not be determined until much longer records are available.

WEATHER BUREAU,
RALEIGH, N. C.

U. S. DEPARTMENT OF AGRICULTURE, WEATHER BUREAU
Station: Asheville, N. C.
Data: Daily Precipitation

1925	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	YEAR
1	T.*		T.		T.	T.	0.26			T.	0.37		
2	T.	0.12	T.							0.27	0.21	0.12	
3	T.	T.											
4			0.24	0.01	0.10		0.03	0.09				0.09	
5			0.05	0.18		T.				0.03	0.03		
6						0.24	T.	T.			T.		
7						0.05	T.			0.41	T.		
8	T.					0.17	0.02	T.			0.44		
9	0.42	0.40			0.02			T.					
10	0.49	T.		0.63	T.		0.05	T.	0.43	T.			
11	0.22	0.55			0.42			T.	T.	0.04		0.01	
12	T.	0.01			0.31				T.		1.10		
13	T.		T.		0.22		0.01		T.				
14		T.	T.	T.	0.01			T.		T.		0.32	
15	T.	0.38				T.	0.08			0.41	0.14	0.03	
16	0.40	0.06	0.44	0.07		0.06	T.	T.	0.27	0.02	T.	0.01	
17	0.40	0.04	0.31	0.30	T.	0.33	0.02	T.		T.			
18	0.38		0.75	T.	0.18	0.22		0.04		0.08			
19	0.41		0.45		0.69	0.17					0.02	0.31	
20	0.01						0.01	0.09		T.	T.		
21							T.	T.	0.03			0.21	
22							0.18		0.19			T.	
23		0.23			T.	0.02			0.71	T.	T.	T.	
24		T.			0.20				0.08	T.			
25		0.05		0.09		0.05			0.25	0.58	0.01		
26	T.	0.01	T.	0.35			T		T.	0.33	0.09		
27	0.01		0.20	0.28							0.02	T.	
28	T.		0.01	0.54			T.		0.04				
29	T.					0.66							
30			T.	T.						0.05		T.	
31							0.11	T.					
Sums...	2.74	1.85	2.45	2.45	2.15	1.97	0.77	0.22	1.92	2.74	2.43	1.10	22.79

* T. denotes trace or less than 0.01 inch.

VARIATION OF PROTEIN CONTENT OF CORN

PAPER V

By H. B. ARBUCKLE and O. J. THIES, JR.

Synopsis of Paper I[1]

1. A rapid Kjeldahl method for the determination of nitrogen in corn; average time of digestion, 35 minutes.
2. Report of analyses of certain varieties chosen for experiment
3. Corn grown in North Carolina from West Virginia seed showed lower protein.

Synopsis of Paper II[2]

1. Brief discussion of facts presented in paper I.
2. Errors arising from using varying amounts of alkali in neutralizing Kjeldahls.
3. Reports of analyses of corn grown in North Carolina and West Virginia.
4. In two samples of corn grown in North Carolina the protein content shows marked increase.
5. Two varieties of corn grown in West Virginia from North Carolina seed show different results. One gave no marked change in protein. The other, a decided increase.
6. Immature corns show low protein in every case.
7. Report of analyses of additional varieties.

Synopsis of Paper III[3]

1. Presentation of analyses to show the effect of fertilizers on protein content of corn.
2. Comments on results.
3. Discussion of variation of protein content of different ears, different parts of the same ear, and different grains of each portion of the ear.

Synopsis of Paper IV[4]

1. Further tests on influence of fertilizers indicate that they have slight effect on protein content.
2. Analyses of several ears of a given sample show distinct variation in protein, which suggests a confused inheritance in our usual varieties.

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[1] Journ. E. M. Sci. Soc. **38**: 84. 1922.
[2] Ibid. **39**: 56. 1923.
[3] Ibid. **40**: 176. 1924.
[4] Ibid. **41**: 64. 1925.

3. Suggestion offered as to importance of increased protein in seed selection of grains rather than ears.

INTRODUCTION

This investigation was undertaken with the purpose of discovering the factors that have a part in the variation of the protein content of corn. The discovery that a certain variety of corn grown in West Virginia, which the students in our laboratory had analyzed for a number of years, showed a different protein content when grown in North Carolina led to this investigation.

After five years, during which our experiments have been attended with many difficulties and interruptions, and since it has become apparent that certain genetic factors interfere with the uniformity of results, it appears well to bring this series of reports to an end.

When we shall secure better opportunities to control more perfectly certain phases of this study, we hope to bring forward any facts worth while on this question of variation of protein in corn. We can not be satisfied with dropping a matter so important just because we have not been able to arrive at very definite conclusions as to the cause of the variations.

EXPERIMENTAL

First we will present certain analyses made of samples grown during the past summer (see tables I–IV).

We shall now gather together in brief compass some of the results of our five years study, placing them before you so that it will be easy to compare them.

1. Results taken from analyses of a few of the varieties studied, designed to show what influence climate may have on protein.

TABLE I

EEE, Golden Dent, seed grown in West Virginia, 1923. Sample grown in West Virginia, 1925. Protein of seed, 9.33%

	PERCENTAGE
Nitrogen:	
No. 1	1.462
No. 2	1.429
No. 3	1.450
Mean	1.447
Protein (Mean)	9.04%

TABLE II

Analysis of seven ears taken from sample of EEE described in Table I

	EAR #1	EAR #2	EAR #3	EAR #4	EAR #5	EAR #6	EAR #7
Nitrogen:							
No. 1	1.512	1.447	1.574	1.754	1.693	1.415	1.278
No. 2	1.481	1.452	1.556	1.731	1.677	1.392	1.274
Mean	1.496	1.449	1.565	1.743	1.685	1.404	1.276
Protein	9.35%	9.06%	9.78%	10.89%	10.53%	8.78%	7.99%

TABLE III

CCC, Silver King, seed grown in West Virginia in 1924; sample grown in West Virginia in 1925. Protein of seed 10.03%

	PERCENTAGE
Nitrogen:	
No. 1	1.604
No. 2	1.595
No. 3	1.584
Mean	1.594
Protein (Mean)	9.97%

TABLE IV

GGG, White Cap, seed grown in North Carolina in 1924; sample grown in North Carolina in 1925

	PERCENTAGE
Nitrogen:	
No. 1	1.612
No. 2	1.601
No. 3	1.614
Mean	1.609
Protein (Mean)	10.06%

Silver King corn grown in West Virginia, with protein content of 8.68%, when grown in North Carolina gave 9.62%.

White Cap corn grown in West Virginia with protein content of 9.84%, when grown in North Carolina gave 10.55%.

Golden Dent corn grown in North Carolina with protein content of 6.68%, grown three successive years in West Virginia gave 8.22%, 10.36%, and 9.04% protein.

These results would seem to indicate that a change in climate causes an increase in protein content.

2. Results taken from our analyses of samples grown with fertilizers, designed to show the effect of fertilizers on protein.

The results of our experiments with fertilizers on four varieties of corn are as follows:

CORN	WITHOUT FERTILIZER	COMPLETE FERTILIZER	PHOSPHORIC ACID	SODIUM NITRATE
Silver King	9.15%	11.04%	8.88%	11.28%
White Plume	9.04%	9.48%	9.10%	9.38%
Golden Dent	10.36%	10.98%	9.33%	9.82%
Goodman Prolific	10.19%			10.50%

The above figures taken from paper III have reference only to the percentage of protein and have no bearing on the effect of the fertilizers on the yield.

Complete fertilizers and sodium nitrate apparently increase the percentage of protein, and phosphoric acid seems to lower the percentage of protein.

The results, however, are not uniform. Compare figures for Silver King and White Plume. Further experimentation is necessary before definite conclusions can be drawn.

3. Analysis of separate ears of three varieties of corn show that the variation of protein content of the several ears of a sample is often greater than the effect of any factor on the average protein of a particular variety.

Separate ears of Silver King grown in West Virginia in 1923 show a range from 8.35% to 10.51% protein. Separate ears of White Cap, grown in North Carolina in 1923 show a range from 7.35% to 7.88%. Separate ears of Golden Dent, grown in West Virginia in 1925 show a range from 7.99% to 10.89%.

The ears of Silver King selected for analysis were as different in physical characteristics as it was possible to secure, and the result is a wide range of variation. The ears of White Cap selected were as much alike in physical characteristics as it was possible to find. There is little variation in protein of these ears, and it is interesting to find that these ears are quite different from the average of this year's sample, which was 8.85%.

The natural inference is that if the ears selected had been dissimilar, the variation of protein would have been wider.

The ears of Golden Dent selected were as different as could be found. The results show a wide range in protein. There were two ears of this

sample very similar; these were #4 and #5 of Table II, above. Note small difference in protein. Ears #6 and #7 were also similar. It thus appears that with some experience in analysis of these corn varieties it would be possible to select ears by physical characters that would have similar protein content. This is evidence of the confused inheritance in our common varieties of corn, and suggests that our problem would be simplified if we could use some original variety of corn that has not acquired much mixed inheritance.

CONCLUSION

In concluding, we may recall a few things of value derived from this study:

1. Development of a quick method of Kjeldahl digestion.
2. Immature corns are low in protein.
3. Grains at butt and tip of ear are lower in protein than grains in the middle.
4. Ears in any sample of corn, if dissimilar in physical characteristics, vary in marked degree in protein.
5. Fertilizers have a slight effect on the protein in corn; apparently, sodium nitrate increases the percentage, phosphoric acid lowers the percentage.
6. Climate and soil give no definite results.

DAVIDSON COLLEGE,
DAVIDSON, N. C.

SUBSTITUTION OF SODIUM COMPOUNDS FOR POTASSIUM COMPOUNDS[1]

By A. R. Smith and F. C. Vilbrandt

In making a survey of the potassium supply of this country it has been found that there are no large central sources, that it seems to be pretty well distributed and rather difficult to obtain economically. Therefore the greater part of this material used in the United States is imported. Germany furnished us most of our supply up until 1914, and will continue to furnish us the major portion for our agricultural demand for several centuries to come.

With the beginning of the World War we were brought face to face with the problem of supplying that which was cut off from us or doing without. The end of the War has alleviated this condition to a considerable extent. But in order to become somewhat independent economically from Germany it is necessary to take stock of our peacetime resources and eliminate waste or misuse of our supply.

We need potash for commercial fertilizers. There is no substitute we can use in place of the potash as a plant food, potash being one of the three main plant foods. The question then arises as to the possibility of substituting some other material in its place in other than fertilizer manufacture. The National Research Council realized the economic possibility of the substitution of sodium for potassium in many processes and chemical operations, and therefore appointed a committee to study this phase of the potash problem.

In Analytical Chemistry there are found a great many methods of determinations in which a potassium compound or compounds are called for. In most of these it is not the potassium ion or cation that is the active agent but the anion. Then why not substitute some other compound or compounds containing the desired anion in the place of the compound containing the potassium ion in this work? The investigation has been undertaken to study, as far as possible, the possibility of substituting mostly sodium compounds in place of potassium compounds. In this particular work Griffin's Technical Methods of

[1] Given at Wake Forest, May 1, 1926.

Analysis was minutely studied. This book covers almost completely all technical analytical determinations used in this country. It was necessary to make comparative determinations with sodium and potassium side by side in order to eliminate, as far as possible, all outside factors that escape ordinary observation. Approximately two hundred determinations were made.

The results of the investigation can be summed up as follows:

1. Sodium, barium, and calcium permanganates may be used interchangeably in place of potassium permanganate in the preparation of standard permanganate solutions; standardization of sodium thiosulfate; standardization of ferrous ammonium sulfate; standardization of indigo carmine solution; determination of phosphorus pentoxide in table salt; purity of sodium nitrite; total calcium in lime sulfur solution; nitrogen in organic substances; nitrogen in nitrates; organic nitrogen soluble in neutral permanganates; organic nitrogen soluble in alkaline permanganates; formic acid in formic acid solution; manganese, chronium and phosphorus in iron, steel and alloys; iron in zinc (spelter); in alum used by paper-makers and in water; tannin in sumac extract; calcium in mortar, concrete, portland cement and water.
2. Sodium iodide may be use in place of potassium iodide in the preparation of standard iodine solution; preparation of Nessler's reagent, and the preparation of zinc chloride-iodine solution; standardization of sodium thiosulfate solution; standardization of sodium dichromate solution; standardization of potassium dichromate solution; standardization of arsenous oxide solution; standardization of iodine solution for iodine jelly test of tung oil; standardization of Wijs solution; in the analysis of sodium nitrite, sodium dichromate, and potassium dichromate; in the determination of antimony oxide in antimony sulfide, total copper oxide in paris green, nickel in alloy steel, red lead in red lead and orange mineral, lead acetate in pigment, rosin in shellac, iodine number of animal and vegetable oils and fats, available chlorine in bleach solutions, bleach consumption of pulp, chromic oxide in chrome liquors, glucose in honey and free chlorine in paper.
3. Sodium hydroxide may be used in place of potassium hydroxide in the preparation of standard caustic solution, Nessler's reagent, alcoholic potash solution, standard potassium cyanide

solution, and standard sodium cyanide solution. It may be used in the determination of unsaponifiable matter in lubricating oil, free fatty acid in greases and cutting compounds, free sulfurous acid in sulfite acid, alkalinity or acidity in alum, acidity of casein, acid number in rosin, cotton cellulose for nitration, fibers in cloth and yarns, methyl silicylate in wintergreen extract, and unsaponifiable matter in sulfonated oils.

4. Alcoholic sodium hydroxide may be used in place of alcoholic potassium hydroxide for determining the saponification number of animal oils and fats, vegetable oils and fats, and lubricating oils. It may also be used for determining methyl esters in menthol.
5. Sodium dichromate may be used in place of potassium dichromate in the preparation of standard dichromate solution and in the preparation of dichromate indicator. It may also be used in standardizing sodium thiosulfate solution; in the determination of lead oxide in lead arsenate, total lead in green graphite pole paint, litharge in red lead and orange mineral, total lead in white lead, lead in blance fixe, lead chromate in chrome yellow, glycerol in soap, and for determining the purity of glycerol.
6. Sodium chromate may be used in place of potassium chromate for the preparation of chromate indicator. It may also be used in the determination of chlorine in sodium cyanide and potassium cyanide, and total lead in lead arsenate.
7. Sodium aluminum sulfate may be used in place of potassium aluminum sulfate in the preparation of alumina cream.
8. Sodium cyanide may be used in place of potassium cyanide in the preparation of standard cyanide solution; in determining nickel in alloy steel, and formaldehyde in formaldehyde solution.
9. Sodium sulfide may be used in place of potassium sulfide in the determination of nitrogen in nitrates and organic materials.
10. Sodium sulfate may be used in place of potassium sulfate in the determination of nitrogen in nitrates and organic materials.
11. Sodium nitrate may be used in place of potassium nitrate in the determination of phosphorus in iron, steel, brass and bronze.
12. Sodium chlorate may be used in place of potassium chlorate in analysis of alloy steel for manganese and molybdenum.
13. Sodium ferrocyanide may be used in place of potassium ferrocyanide in testing paper for penetration power.

In only two instances was it found that good results were not obtainable; these were the saponification numbers of beeswax and rosin with alcoholic sodium hydroxide. However, similar results were obtained with alcoholic potash.

We may conclude then from this investigation that sodium compounds may replace almost in whole potassium compounds in technical methods of analysis.

CLASSIFICATION OF COTTON BY MICROSCOPY

By W. M. Mebane and F. C. Vilbrandt

Much criticism and discrimination has been directed against North Carolina upland cotton recently by foreign interests. It occurred that the basis of this discrimination may have been due to the dry weather that occurred during the growing season or to the rather non-uniformity of collection of cotton by the laborers and tenant farmers, introducing into the stock a mixture of cotton subjected to all conditions of growth.

Samples were collected from selected fields under varying weather and plant conditions. They were classified as green, ripe, over-ripe, and frost-bitten samples. Slides were made of each sample collected and observations made under the microscope under various lighting conditions to ascertain the condition of the individual fibers. The seed from the samples were subjected to the "rag doll" test of the United States Department of Agriculture, and their weight ratio to the cotton was determined.

The results of this study showed that the ratio cotton to seed was greater for the green and after-frost samples, and less for the medium and over-ripe samples. The over-ripe samples showed a ratio less than the medium, and the after-frost less than the green samples. The percentage of germination in the rag doll test showed a similar variance. The percentage of the various types of fibers was estimated by counting the fibers shown in the slides. The samples collected as green were estimated at 16% good fiber, 22% underdeveloped, 32% green, and 30% dead fiber. The medium showed 53% good, 5% underdeveloped, 4% green, and 17% dead fiber. The over-ripe showed 47% good, 20% underdeveloped, and 36% dead fiber. The after-frost showed 50% good, 6% underdeveloped, and 44% dead fiber.

It is apparent that the weather, the condition of the soil and the time of picking directly influence the kind of fiber produced by the plant. In addition the ratio of cotton fiber to seed show a distinct relationship to the "rag doll" tests, either one representing an easy and distinct method of classifying cotton.

It is also apparent from the results that the greatest need of the cotton growers in the production of a better product is a classification

of the fibers as to the condition of the fibers as well as on the length. According to the results of these examinations the time to pick the cotton to get the best results is when the boll is wide open and the cotton is standing out firmly. This would of course necessitate more frequent picking over the field, but it would save a large percentage of the cotton which is both picked before ripe and which is allowed to fall. The underdeveloped and dead cotton are wasted when collected and woven into fabrics in which they do more harm than good. It is reasonable to expect that the cotton picked at the best time and properly classified should demand a price in proportion to the extra work required to produce it, because the examination of the products of some of our textile mills shows that there is a need of adjustment somewhere. The fact that the European consumers of cotton are preferring other cotton to that grown in the South shows that there is something wrong with it, and it appears to be that the large percentage of imperfect fibers make it undesirable to those who wish to make high class materials from it.

The above examination of cotton for the condition of the fibers is not difficult. Herzog proved that he could predict the results of a mercerization by a microscopic examination of the raw stock, and by such methods the finishers can judge the value of the yarn before they buy it. This method should prove invaluable to manufacturers of such type of cotton fabrics. The need of supervision of cotton picking is self evident.

In an effort to apply the information obtained by the microscopic methods on the cotton selected for study, samples of various commercial fabrics claimed to have been manufactured from native stock were obtained from the local goods store and examined to note any defects from the presence of dead or underdeveloped fibers, if such were present, in the finished fabrics.

A sample of the fibers of a cotton handkerchief that had not been mercerized was examined. The examination showed 35% of the fibers to be dead or badly underdeveloped.

Another sample of mercerized cotton was examined. It was found to contain green and dead fibers. The dead fibers showed no change in form from the process of mercerization, and the green ones were the same as before treatment, and but for their smaller size and smoothness looked very much like mercerized fibers. The imperfect fibers amounted to 25% of the total.

The lint on cotton flannel showed green, unripe, and dead fibers, amounting to 30% of the total.

A sample of yellow denim showed the dead fibers dyed brown, the

good fibers yellow, and the green ones not dyed at all. About 25% of the fibers were imperfect.

The examination of light unbleached domestic showed about 45% imperfect. There were half ripe, green, dead, and spotted fibers in the sample.

The examination of a black and white dress goods showed in the black portion the small green fibers dyed jet black, the thin ribbons of dead cotton a very pale black, and the fully developed cotton a medium shade, but spotted and streaked. Crossed nicols showed dead fibers black, good ones pale spotted, and green ones light colored. The white or undyed portion of the fabric showed dead and undeveloped fibers.

A light pink colored cloth contained about 15% good cotton. The remainder was either green or dead. Only the good fibers were dyed a good pink color. The dead ones showed no color and the green ones were spotted with the dye to a slight extent.

A dress goods composed of interwoven black, pink and white threads contained a large number of undyed fibers due to faulty application. Where the yarn was tightly twisted the dye did not penetrate. Of the pink only the dead fibers were dyed, and they were dark red. In the black only one in one hundred was dyed, and in the light black one in twenty-five. A low magnification was used to count a cross section of the threads and it was found that of the total only 33% were dyed at all.

A sample of buff and blue dress goods appeared to come from unripe bolls. The fibers were all badly formed and many of them were dead. Of the blue portion 30% were dyed. The dead fibers were slightly colored, and the green ones not at all. The fibers were all lacking in twist.

One of the greatest needs of standardizing the quality of raw cotton is to produce a yarn that will dye evenly. One cannot impart a full rich color to a fabric when only a small percentage of the fibers are dyed. The same applies to mercerization, because a dead fiber will not respond to the treatment that is given the textile to produce the smooth appearance.

The imperfect or poorer grades of cotton would be more useful in the cellulose industries that use cotton as a raw product than for textile manufacture. P. G. Sanford has shown that dead and underdeveloped cotton nitrates more easily than the better grades. There is an increased use of nitrocellulose for lacquers as well as for other purposes,

and underdeveloped cotton would be more useful for nitrocellulose manufacture than fully developed fibers because it responds more readily to nitration treatment than ripe fiber.

There does not appear to be any good use for green fibers and there does not exist any reason for cotton to be picked from the boll in such condition except the desire of the picker to get all he can from the crop under the present system of classification, or the lassitude in the collection of cotton, the application of the system of few and vigorous pickings of the fields.

UTILIZATION OF NORTH CAROLINA COALS[1]

By Frank C. Vilbrandt

Very little attention has been paid to North Carolina coals, as is evident by the absence of analyses and comments on this coal in the compilations of North American coals. It is true that the coal field is small, that the quantity of coal in the measures in the Deep River Valley could be consumed with ease if the entire United States were to draw wholly upon this field, but the coal found in this state is of economical importance as a high grade by-producting coal, more important as a by-product coal than as a straight furnace or steam coal.

Until last year surveys and estimates on the Deep River field were made on the basis of outcrop and mine face data. One of the companies operating in this field has recently completed a very extensive and costly underground survey, obtaining data sufficiently satisfactory to them to cause them to invest more money and to improve methods of transportation of the coal from the mines in order to increase production. With increased production, more efficient utilization of the coals will result.

The coal field of North Carolina lies in the Deep River Valley of Chatham, Moore and Lee Counties, the only operations carried on at present being in the measures northwest of Sanford, near Cumnock and Gulf. It has been variously estimated to contain 100,000,000 tons of usable coal at depths not exceeding 1500 feet.

The coal from this field is brilliant black, retaining this lustre on pulverizing; the fracture is conchoidal. When mined the coal is hard and in lumps, but on exposure to the air it disintegrates very shortly to fines, leaving only a small portion as lump. Sulfur appears mainly as 'ball sulfur.'

The outstanding characteristic of this coal is the ease of production of excessive amounts of smoke, soot and flare-backs. For these reasons this coal finds disfavor as a household fuel and under manual firing methods greatly reduces the efficiency of steam power plants. It is claimed that the use of this particular coal on the fleet blockade runners

[1] Paper read at Wake Forest, May 1, N. C. Section American Chemical Society.

of the Confederacy plying between Wilmington and England, due to its excessive smokiness, enabled the ready spotting and capture of these ships.

Inasmuch as the efficiency of steam boilers depends largely upon the quantity and nature of those constituents of coal that can be gasified at a low temperature, but which do not condense upon the boiler surfaces, or which are not reduced below the temperature for their complete combustion, an evaluation of the Deep River coals from the above viewpoint is necessary to explain why these coals produce reduced efficiency in steam power plants. Studies by Giles and Vilbrandt[2] in which the coals from this field were subjected to maintained low temperatures for long periods of time, and in which the products of such low temperature distillations were carefully analyzed, disclose some of the reasons for the excessive smokiness of this coal. The production of large quantities and the rapid evolution of decomposition products together with excessive sooting and disintegration at low temperatures make this coal impractical for use in power plants using the hand firing methods.

The excessive smokiness is attributed to the presence or formation of the higher hydrocarbons of the paraffine series and the excessive rate of evolution by pyrolysis. In the early stages of heating the nature of the volatile products distilled from the different samples of coal at low temperatures varies according to the smoke producing tendencies of the coal. According to the analyses of the gases evolved in the low temperature distillation of the coal large quantities of heavy hydrocarbons were formed. The high volatility of these gases does not permit them to remain in the heat zone any great length of time, so that secondary decomposition of the gases is restricted. This gas evolved at low temperatures by itself would be too rich and have too great a sooting tendency to make it applicable as a domestic heating gas. The gaseous products liberated at higher temperatures are poorer and do not produce soot readily. The mixture of the two types of gas would make an admirable fuel.

The initial decomposition point of this coal occurs at 540°C.; the evolution of gas at this temperature is quite rapid and accompanied by a rapid disintegration of the burning coal. The secondary decomposition point occurs at 700°C., the products formed or evolved at and above this temperature differing greatly from those produced below this point.

[2] Industrial and Engineering Chemistry, Vol. 16, No. 8, page 779. August, 1924.

The evolution of large quantities of gases at low temperatures is the cause for the flare-backs and explosions that occur in heating stoves when careless firing is done.

Data on the low temperature distillation of this coal has been published by Giles and Vilbrandt.[2] Following is a compilation of the analyses of eight samples of coal taken from different coal measures in the field, only numbers one to four being utilized at present as a salable coal. The other analyses were made to obtain information on the coal-like substances and middlemen with a view of ascertaining their possible economic utilization as powdered fuels. The removal of this salable or usable material would also create more head room in the workings.

At the present time not all of the above coals are taken out for consumption, but in many places in the mines it becomes necessary to remove some of these poor grade coals to make working head room. If

TABLE 1

Analyses of Deep River Valley coals

SAMPLE	MOISTURE	VOLATILE MATTER	FIXED CARBON	ASH	SULFUR	B.T.U.
	%	%	%	%	%	
1	1.00	37.80	51.95	9.03	0.22	14,330
2	0.84	27.80	66.00	5.37	1.30	13,480
3	1.30	33.17	56.64	8.75	2.42	13,460
4	1.13	32.87	57.61	8.37	2.76	13,450
5	0.53	26.97	50.85	21.65	2.33	11,600
6	2.93	31.64	35.44	28.61	2.21	10,560
7	2.42	18.26	53.52	24.92	1.55	11,200
8	1.15	24.89	55.15	15.64	3.17	12,230

coals similar to samples five to eight can be commercially used, the attending ease of working and mining would decrease the per ton cost of bringing to the surface the coals now mined. In order to eliminate as much as possible the handling and haulage to the surface of 'rock' or poor grade coal for which there is no sale at present, one of the operators keeps a very close check by analyses of the coals brought to the surface.

In order to economically use the coal that is at present classified as salable coal it will be necessary to use mechanical stokers. The first four coals are high volatile coals. Number two is a superior kind, but as with the others, the analyses do not indicate that these coals give off the volatile matter they do contain at a rapid rate. Number two is almost as smoky as the others. As such there is no doubt as to the in-

applicability of these coals in the boiler rooms of power plants, most of the heat being lost by excessive smoke production and the rapid evolution of by-products making combustion difficult and also dangerous if firing doors are promiscuously opened. Mechanical underfed stokers, which would, by different zone temperatures, liberate the rapidly evolved gases below the fire zone and permit its combustion, would permit this coal to be used in steam power production.

The ease with which this coal disintegrates in the air and its ready evolution of combustible gases and disintegrated coal dust at low temperatures, points out another very excellent method of utilization of this coal for steam production or for industrial heating purposes. The rapid strides made in the use of powdered fuels with the progress made in fueling machinery to accomplish this, points also to early advances in industrial development with these coals.

TABLE 2

Analyses of coke still residues of Deep River coal

HEAT TREATMENT TEMPERATURE	VOLATILE MATTER	ASH	SULFUR	FIXED CARBON	B.T.U.
°C.	%	%	%	%	
Original coal	37.80	9.03	0.22	51.95	14,330
200	26.82	9.25	0.22	63.71	14,280
300	8.95	9.31	0.04	81.70	14,210
360	3.40	9.80	0.03	86.77	14,130
420	2.53	10.05	0.03	87.39	14,090
480	1.61	10.29	0.03	88.07	14,060
540	0.93	10.02	0.03	89.03	14,050
600	0.37	10.49		89.14	14,030
660	0.12	10.77		89.11	14,000

Examination of residues after low temperature distillation show that the coal can be converted into suitable domestic, low volatile, and smokeless coal or a good grade of coke. The residues obtained up to 300°C. heat treatment retained the appearance of the original coal. At 360°C. sufficient tars had been liberated to cement the residue into lumps. As the temperature was increased the residue lost more of the tar binder and began to take on the appearance of commercial coke. At and above 540°C. the residues were hard, flinty, and honey combed. The volatile matter, sulfur and B.t.u. decreased with increasing still temperatures, while the fixed carbon and ash increased. Heating just above 360°C. produces a coaly coke with the volatile matter percentage reduced to 8.95, while above 540°C. the volatile matter dropped to 1.00 per cent.

By proper temperature control, a fuel could be produced which would retain its lumpiness, eliminate flare-backs and sooting and excessive smokiness. Heat treatment data on sample number one low temperature coke residues are compiled in table 2.

The gas obtained in the by-producting of this coal could be utilized by hydro-electric plants in the Deep River Valley or with the quantity production of this commodity, other industries dependent upon cheap gas would subsequently locate in this field.

A by-products recovery plant would furnish light oils for solvent purposes, benzol for blending into motor spirits, coal tar substances for dye intermediates, roofing tars and pitches, cheap road tars, ammonium sulfate for fertilizer and coke. The coke could not be used for metallurgical purposes on account of the sulfur, but it would make an excellent water gas coke for the production of heating gas for municipalities, or the coke could be used directly as a smokeless, high heat-efficiency, domestic fuel.

Efficient utilization of this coal will mean new industries to the state. It is possible that in the future the people of North Carolina may use North Carolina ammonium sulfate fertilizers in their fields, North Carolina motor spirits in their automobiles, and North Carolina asphalt shingles on their roofs; that they may drive over roads tarred with North Carolina tar products, and cook with gas produced from North Carolina coal or its by-product, coke; and they may use textiles not only woven from North Carolina cotton in North Carolina mills, but also dyed with dyes manufactured from North Carolina raw materials.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

STUDIES ON DEODORIZING MENHADEN FISH OIL

By E. E. Randolph

That the Menhaden fish industry is one of the major industries of the state is evident from the following facts:

Value of plants, fixtures, boats, and seines	$4,565,000
Value of the crude oil at plants	564,000
Value of the fish scrap at plants	646,000
Total value of annual output at plants	1,210,000
The number of gallons of crude oil produced	1,088,000

The average price for the oil is 6½ cents a pound, or 50 cents a gallon.

The eleven large plants in actual operation are located as follows: Three at Morehead City; three at Beaufort; five at Southport; the sixth plant is under construction at Southport, costing $200,000. The Fisheries Products Company have built an immense plant at Wilmington, valued at $2,400,000. The number of fish caught in North Carolina last season was 225,000,000.

The Department of Commerce announces that the factory production of fats and oils during the past quarter was: 802,192,167 pounds of vegetable oils; 16,561,582 pounds of fish oils; 593,716,767 pounds of animal fats; and 98,000,000 pounds of grease—a total of over 1,500,000,000. The economic output of many of these oils has just about reached the maximum. As our population and needs increase we are naturally interested in finding other sources of these supplies, or of improving the quality of some of the inferior kinds in order to make them available for food and for other high grade uses.

Fish oil is not at present used for food, although is contains highly desirable food values. The principal uses of fish oil are for tempering steel, for adulterating cod liver oil and linseed oil, for currying leather in the tannery, for linoleum manufacturing, and for soap making.

Menhaden oil is especially useful as a carrier for paints for metal which is subjected to varying temperatures. It has no equal for smoke stack paint, because it forms a rubberlike film which is very elastic.

The fish are caught in seines, hurried to the shores in schooners or motor boats, unloaded immediately in trams of definite measure, dumped into vats with false bottoms under which are open steam coils. The fish are steamed until disintegration takes place. Some modern

cookers are arranged with continuous conveyors. The oil rises to the top of the vat and is drawn off. The scrap is pressed for a second quality of oil. Then it is dried and pulverized for fertilizer and to enrich feedstuffs with its protein. Rotary driers are replacing the more primitive sundrying system.

The best quality of oil is prepared from the fresh fish by the steaming process. This oil is of a pale yellow color and has a rather pleasant odor and not a disagreeable taste. This quality of oil separates stearine when chilled, yielding a winter white oil. Fish which are not fresh yield a much inferior oil. Long cooking also darkens the oil.

Completely hydrogenated oil loses its odor, and when made from fresh oil from fresh fish is recommended by authorities for lard.

Investigations have been carried on last year in the Chemical Engineering Laboratory of State College by Mr. Arthur, now of Morehead City, and this year by Mr. Chen and Mr. Chu, in an effort to remove the color, odor and taste from Menhaden oil. The object of this investigation is to find practical methods for preparing this oil for food and to enlarge the economic uses of this oil. The oil is especially rich in vitamins.

The oil has an iodine value 145–170, saponification number 190–195, specific gravity .9281–.9349, free acid number 2.8–11.7. The odor seems to be due largely to unsaturated acid and to amines from protein matter. Twitchell found that the oil contains 22.7% palmitic acid, 9.2% myristic acid, 1.8% stearic acid, and unsaturated acids which he thought contained 18, 20, and 22 atoms of carbon.

Since the glycerides are easily saponifiable, caustic soda is not feasible as a purifying agent as it is with vegetable oils. Among the important methods which have been proposed are (a) the formation of a lime emulsion and evaporation in vacuo; (b) the oil is heated to 100° with lime water sprayed in by a steam injector; (c) use a saturated solution of alum and heat with superheated steam to 110° and keep at 80° until sedimentation is complete; (d) the oil is treated with char and chalk and superheated steam; (e) atomize the oil against a blast of hot air, or better to use a non-oxidizing hot gas.

A successful method for deodorizing the oil was devised as follows: the oil was gently heated with formaldehyde and a few cubic centimeters of concentrated HCl. This treatment removed a considerable amount of protein and mucilaginous matter as a gluey resinous-looking precipitate, and improved the odor considerably. Superheated steam was then led through the oil for 2½ hours, removing the excess formaldehyde and further improving the oil, and left it free from condensation prod-

ucts. The oil was further improved by using atomized lime water and superheated steam. In another case chalk and char were used instead of the lime. A still better way was to use alum instead of the chalk. When this oil was bleached it remained odorless up to 110°C. After 2 hours treatment the iodine value had dropped from 155 to 121. Cod liver oil for medicinal use is blown for 24 hours and the iodine value drops from 163 to 117. The fact that oil which had been treated with formaldehyde did not oxidize readily, or not at all, seemed to indicate that the unsaturated acids had been largely removed, and further that the odor seems to be due to the unsaturated acids. The formaldehyde removed the proteins and mucilaginous matter as condensation products and prevented the oil from oxidation during the removal of the unsaturated acids. The mucilaginous matter seems to act as a protective colloid for the color pigments because its removal by the formaldehyde makes the bleaching materials more effective. A difference of 12.9% black removal on the tintphotometer was observed in the formaldehyde-treated oil, partly due to the protective action of the protein matter, and partly due, presumably, to the pores of the carbon becoming clogged with the mucilaginous matter.

Other methods promise some value, such as the oxidation of the unsaturated acids with such oxidation agents as permanganate or sodium nitrite.

Not being satisfied with the experimental method wholly, we decided to center our efforts to find the real cause of the odor in the oil. Gathering our cue from the fact that the oil very readily absorbs hydrogen on hydrogenation, we decided to try to isolate the unsaturated acids. Our efforts seem to indicate that we have identified $C_{18}H_{28}O_2$ as a main factor in the odor of the oil. Tsujimoto has stated that this acid is present in Japanese sardine oil. Lewkowitech describes the acid as a pale yellow liquid, easily oxidized, changing to a dry, varnish-like mass within a few days.

Five hundred grams of the oil were poured into a flask provided with a reflux condenser. Then 400 cc. of alcohol, and 400 cc. of sodium hydroxide, sp. gr. 1.4, were added and heated with constant stirring until saponification was complete. The soap was dissolved in 10 liters of water and boiled to remove the adhering alcohol. The soap was then decomposed with sulphuric acid and boiled several hours, until the fatty acids separated into a clear oily layer. The fatty acids were now washed several times with hot distilled water until all the mineral acid was removed. They were kept warm and separated from the water and impurities.

The fatty acids were dissolved in glacial acetic acid, and the solution was cooled in a corked flask to 5°. At 5° the bromination was accomplished by adding bromine through a dropping funnel with regular stirring by an electric agitator.

Bromine was readily absorbed and was added until a permanent red color appeared. The bromine derivative settled out as an amorphous waxy body. The flask was kept chilled 3 hours. (It does not seem that the bromine united with the saturated acids—palmitic, myristic, and stearic—in the cold, since such a combination would be a substitution and not an addition product, which reaction would not probably take place in the cold.) The brominated body was washed with a large amount of ether at 5° in order to get a pure body freed from excess of bromine, glacial acetic acid, and any other non-brominated bodies, such as saturated fatty acids. This bromine compound is an amorphous, grayish white substance. It was dried in a vacuum oven. The percentage of bromine was determined by the Bacon and Volhard methods. Judging from the readiness of the oil to absorb hydrogen and of the free fatty acids to absorb bromine, we thought that we must have a highly unsaturated acid. From this idea we undertook to find if we may have had a mixture of unsaturated acids or a mixture of bromine derivatives of a single acid; because the bromine analysis of 48% was lower than we expected. We therefore treated the bromine derivative body with cold benzene. Part of the body was dissolved. The undissolved part was dried in a vacuum oven and its bromine content determined. This was found to be 68.4%, very near the theoretical bromine per cent in $C_{18}H_{28}$- Br_8O_2. This bromine derivative was determined by combustion analysis yielding carbon and hydrogen in approximately the theoretical per cent of C and H corresponding to the above formula. This bromine derivative was reconverted into its acid by reduction with nascent hydrogen by using zinc and hydrogen chloride in the alcoholic suspension of the bromine derivative. The acid obtained is a pale yellow liquid with a concentrated fishy odor. The octobromide had no fishy odor. The combustion analysis of this acid yielded

$$\begin{aligned} C &= 77.96\% \div 12 = 6.49 \div 0.73 = 8.9 \times 2 = 17.8 \\ H &= 10.23\% \div 1.008 = 10.15 \div 0.73 = 13.9 \times 2 = 27.8 \\ O &= 11.71\% \div 16 = 0.73 \div 0.73 = 1.0 \times 2 = 2 \end{aligned}$$

corresponding to the formula $C_{18}H_{28}O_2$ = mol. wt. 276. The molecular weight determined by the freezing point method in benzene was 279.6. The work and analyses were done by Messrs. Chu and Chen.

STATE COLLEGE,
RALEIGH, N. C.

NON-PROTEIN ANTIGENS OF THE BACTERIA

By J. Freund

In research work for the prevention and cure of infectious diseases the question of antigens has always occupied a prominent place. The purpose of this talk is to give a brief review of the literature dealing with the non-protein antigens, and also to give an account of our own work concerning the diphtheria bacilli.

A few years ago it was thought that antigens were substances of biological origin capable of inducing antibody formation when injected into animals and of reacting with antibodies *in vitro*, and that all of the different antigens belonged to one chemical group of substances, namely to the proteins. No antigen effect without protein was a thesis generally accepted. It was supposed that the size and the colloidal state of the protein molecule had a special rôle in the antigenic effect, and the fact that one of the proteins, namely gelatine, is not capable of inciting antibody formation was explained by its molecular weight being considerably smaller than the weight of the other proteins.

In the last year our view about the exclusive significance of the proteins as antigens has been definitely changed. Due to the combination of the method of biological chemistry and immunology our knowledge of antigens has been amplified. Recently new evidences were found for some of the earlier statements concerning the antigenic effect of certain non-proteins, namely lipoid substances, and then some new substances belonging to the carbohydrates were discovered and isolated. Avery and Heidelberger of the Rockefeller Institute discovered that in the pneumococcus in the urine of a pneumonia patient there is an antigen present which is distinctly different from the well known protein antigen of the pneumococcus. This carbohydrate is a very active antigen in test tube, giving precipitation with the pneumococcus antiserum in a dilution 1:5 million. An antibody reacting with this substance is produced only when whole bacteria are injected into rabbits, but when the isolated carbohydrate is injected the rabbit does not respond with antibody formation. Two years ago Muller and Tomcsik described a carbohydrate antigen found in yeast, which is also very active in the precipitation test, but without biological effect after separation from the

yeast cell. Just a few months ago another gum substance was isolated in the tubercle bacillus by Muller in this country, and at the same time, but independently, by Laidlow and Dudley in England. This gum is very active in the precipitation test, gives no complement fixation, and does not induce antibody formation when injected after separation from the bacillus. These three substances differ from the protein antigen very distinctly in their lack of biological effectiveness, since all the studied protein antigens act antigenically *in vivo*. In connection with this it is very interesting to discuss the characteristics of the so-called heterogenetic antigens. Forsman discovered in 1911 that antigens which are present in the red-blood cells of the sheep, and are responsible for the hemolysis production when we inject the red blood cells of sheep into rabbits, are also present in different species of animals without any connection of their natural relation. For example, emulsion of guinea pig kidney or horse kidney injected into rabbits induces antibody formation against sheep blood cells. It was established that this so called heterogenetic antigen is not a protein, and is soluble in hot alcohol. It is a lipoid antigen. Unlike the proteins and similar to the carbohydrate antigens the lipoid heterogenetic antigen, though it reacts very powerfully *in vitro*, induces antibody formation only very slightly when injected after separation from the other parts of the cells. It would be logical to suppose than an alcoholic extract of sheep cells would act as antigen *in vivo* if we would reunite this alcohol extract with the constituents of the sheep cells from which it was separated. But this is not the case. The negative result obtained with such a combination of lipoids and the remaining parts of the organs did not prevent Landsteiner of the Rockefeller Institute from trying other combinations. He supposed that the heterogenetic lipoid antigen occurs in nature as a part of a chemical unit or molecule and that the other part is a protein which enables the lipoid part to act *in vivo* as antigen. In fact he found that several proteins, for instance those of hog serum, when combined with the heterogenetic antigens, and injected into rabbits together, restores the lost potency of the heterogenetic antigens to incite antibody formation. For such substances Landsteiner proposed the term "haptene." By haptene we understand a substance which is capable of reacting with antibodies *in vitro*, but lacks the potency to induce antibody formation *in vivo*.

More than fifteen years ago Kurt Meyer made the statement that he found ether and alcohol soluble antigens in the tubercle bacillus and certain tenias. This statement was received with scepticism. The

evidences for his statement were not sufficient to exclude the possibility that his substance was not contaminated with the protein antigens of the tubercle bacillus. Conclusive proofs for the separate existence of the alcohol soluble antigens were furnished by Dr. Dienes of Asheville.

He has shown that the sera obtained from rabbits injected with the protein of tubercle bacilli react *in vitro* only with the protein and do not react with the alcohol soluble antigen. On the other hand sera obtained by the injection of the lipoid antigen react only with the lipoid antigens *in vitro*. Similar lipoid antigens were found in the acid-fast bacteria: *Bacillus phlei*, *B. smegma*, so-called *B. lepra*. These lipoid antigens react not only *in vitro*, but they incite antibody production when injected into rabbits, without the addition of another substance. These lipoids are very active in the complement fixation test. Even somewhat less than 0.001 of a milligram of the dry material is capable of giving positive complement fixation. When Dr. Dienes purified this lipoid antigen by precipitation with aceton and washing with HCl he was able to obtain preparations with higher potency, 0.0002 mg. being the unit for complement fixation in the most potent preparations. That this antigen is not contaminated with protein is demonstrated by the low content of N2. It contains 0.2% N2, while the protein contains 14–16%. Recently Dr. Dienes succeeded in further purification of the lipoid antigen of tubercle bacillus. He separated the lipoid substance in two fractions. One of the fractions contains about 15% fatty acids, 7% P, and 0.5% N2, and is five times more active than the original preparation, the smallest complement binding dose being 0.00004 mg. The other part contains 80% fatty acids, 1% P, and is only slightly active. The very active fraction contains 17% carbohydrates, is soluble in water, and aceton, whereas the original extract was insoluble in these solvents. The thorough change of solubility indicates that the active fraction of the lipoid molecule was separated by a chemical splitting. According to this the so-called lipoid antigen of tubercle bacillus occurs in the alcohol extract as a lipoid, but in the separated purified form it is not a lipoid. This antigen which is so active *in vitro* was not studied as to its effect *in vivo*.

Last year we made an effort to ascertain if microorganisms other than the acid-fast bacilli contained alcohol-soluble antigens, and we studied the lipoid antigen of the diphtheria bacillus which had been previously found. In the case of yeast, aktinomyces, trychophyton, terosis and staphylococcus we were not able to demonstrate the presence of an alcohol-soluble antigen, although the rabbit sera obtained after treat-

ment with these micro-organisms gave positive complement fixation with the respective suspension of the micro-organisms. This cannot be regarded as a final proof for the absence of alcohol-soluble antigens, as other perhaps newly cultivated strains would incite antibody production for the antigen in question. But we were successful in demonstrating an alcohol-soluble antigen in the streptothrix. The serum of rabbits which received six injections of broth culture of streptothrix gave positive complement fixation with the suspension of the micro-organisms in a dilution of the serum 1:300 and with alcohol-soluble antigen 1:40. The smallest dose of the alcohol extract giving complement fixation was 0.0003 cc. which corresponds to 0.002 mg. dry material. A closer study of the chemical nature of this antigen is in progress.

As we said before, the alcohol-soluble antigen of the diphtheria bacillus was demonstrated years ago. We found that this lipoid is distinguishable from the lipoid antigen of tubercle bacilli and from that of streptothrix. A serum obtained from rabbits by intravenous injection of the whole emulsion of diphtheria bacilli gave positive complement fixation with the whole emulsion in a dilution 1:160, and with the lipoid antigen, 1:80. The smallest dose of the lipoid antigen giving complement fixation is 0.001 mg. dry material. It is soluble in aceton, and not soluble in ether, which is the opposite to what was found with the specific lipoid of tubercle bacillus. It is precipitated by acid, and dissolved by weak alkali. In most purified form its smallest complement fixing unit is 0.00034 mgm. It contains no reducing carbohydrate, and we could demonstrate no fatty acid. It contains almost 9% N2, but gives no biuret reaction.

Dilution of the alcohol extract 1–500 gives positive precipitation test with the immune serum, using the ring-test method.

The biological significance of the known protein antigens of the bacteria has not been established. Boquet and Negre of the Pasteur Institute in Paris claim that injection of alcohol extract of tubercle bacilli prolonged the lives of guinea pigs infected with tuberculosis, but these observations have not yet been confirmed by others. Outside of this no protective effect of any of the alcohol-soluble antigens was demonstrated. The alcohol extract of tubercle bacilli is not anaphylactogene.

We can assume that there is some biological significance attached to these substances, which is not yet known, but which when discovered may open some new avenues in immunology.

VON RUCK LABORATORY,
ASHEVILLE, N. C.

NEW WATER MOLDS FROM THE SOIL

By W. C. Coker and H. H. Braxton

Plates 10–15

Since the publication of Mr. Harvey's paper in this Journal (**41**: 151. 1925), several members of our botanical staff have continued the study of the soil fungi of Chapel Hill and also of eastern sections of North Carolina. A number of new species have been found and other known species have been grown for the first time from the soil. In addition to these we are adding notes extending the distribution of certain water molds that have been found in water in North and South Carolina.

All new species and forms included below are described from cultures grown from a single spore. Except for the two drawings of *Aphanomyces euteiches* the figures were drawn by Mr. Braxton. Some of them were inked in by Miss Alma Holland.

Allomyces moniliformis n.sp.

Plate 10

Growth dense, reaching a length of 7 mm. on a boiled hemp seed. Hyphae about 10–48μ thick, growing gradually more slender at each joint, basal joints from 45–150μ long, those of central region up to about 655μ long; tips blunt, hyaline. Primary sporangia cylindrical, from 2.5–4.5 times as long as broad, 23–32 x 62–135μ; secondary sporangia mostly formed beneath the primary ones, forming long, usually much branched chains in old cultures, up to about 28 in a single straight row, with the younger ones gradually becoming smaller and more nearly spherical, the basal ones as small as 20μ in diameter. The protoplasm in the sporangia becomes pink about the time the outlines of the spores appear, and gradually becomes browner as the spores develop. Spores 10–16.8μ in diameter, average 13–15μ, monoplanetic, escaping singly through one to four holes or short papillae, oval when swimming, amoeboid before encysting. Resting bodies appearing after two and a half or three days, of the same shape as the primary sporangia, except shorter, 21–35 x 43–66μ, with conspicuous pits as in *A. arbuscula*, at maturity slipping from the thin, clasping sheath (germination not yet seen).

Found three times: once in moist sand five inches deep under *Hydrocotyle* on Smith Island, N. C., (type locality), May 15, 1926; twice in soil by Pigeon River in Haywood Co., N. C., July 24 and 27, 1926. [Note: Smith Island has a climate about like that of northern Florida. The tree palmetto (*Sabal*) grows there, reaching a height of 35 feet.]

This species is easily distinguished from *A. arbuscula* by the elongated primary sporangia, long, moniliform, branched chains of secondary sporangia, and by the elongated resting bodies which are colored pink until near maturity. The vegetative structure is not strikingly different. (*A. arbuscula* also reaches a length of 7 mm. on hemp seed.) Habitat in soil does not distinguish it, as we also find the other species there.

Thrausthotheca unisperma n.sp.

Plate 11, figs. 1–7; pl. 12, figs. 1–6

Growth fairly dense on boiled hemp seed, jimson weed seed and mushroom grubs, reaching a length of 8 mm. under good conditions. Main hyphae from 10–68μ thick at base, freely branched into secondary branches, mostly from 18–33μ thick; growing tips pointed and hyaline. Sporangia abundant, long-cylindrical, a few short clavate ones appearing in young cultures, 18–30 x 55–370μ, generally 23–28 x 190–350μ; primary ones terminal on main branches, secondary ones formed by cymose branching; thicker than the hyphae bearing them and generally thicker in the distal half, with spores occasionally borne in a single row. Sporangial wall very thin, completely disappearing as the spores escape, except for a small basal cup that often remains. Spores 10–16.5μ in diameter, abnormal ones sometimes reaching 20μ; escaping by the rupture of the sporangial wall at any point, as base, side, or tip, or by the seemingly complete disappearance of the sporangial wall, leaving the encysted and somewhat angular spores free to exude in all directions; after arrest the spores escape and swim away as usual. Oogonia abundant in nearly all cultures, appearing when cultures are 6–8 days old; borne on long, slender, often branched, bent or sometimes once coiled branches of 4.5–6μ diameter. These oogonial stalks with their antheridia often form a very dense, untraceable, conglomerate growth. Oogonia 15–24μ, generally 19–22.5μ in diameter, abnormal ones up to 39μ, spherical to oval, often very irregular, and with outgrowths up to 6–7μ long; oogonial wall varying greatly in thickness in the same oogonium, from 1.6μ to almost no thickness. Eggs spherical, single in the oogonium and not filling it, from 12–19.5μ in diameter, generally 14–18μ, eccentric; with a single, large, round oil drop on one side. Antheridia androgynous, on from 25–65% of the oogonia in most cultures, borne as a rule on the oogonial stalks, generally profusely branched and irregular, with from one to many finger-like projections touching the oogonia. No antheridial tubes have yet been observed.

Collected three times from Chapel Hill soil, once from moist gravelly loam one inch deep under grass behind the Presbyterian Church, March 6, 1926, and twice from garden soil, March 17, 1926, under an old corn plant and under spinach.

This species differs strikingly from *T. clavata* and *T. achlyoides* in the much smaller, irregular oogonia, the single, smaller eggs, and the more limited vegetative growth. From the former it also differs in the elongated sporangia and from the latter in the method of spore escape and the eccentric egg. In *Achlya dubia* some of the sporangia look and behave like those of the present plant but otherwise the two are quite unlike.

Thraustotheca unisperma var. **litoralis** n. var.

Plate 11, figs. 8–13

Growth short on boiled hemp seed, reaching a length of 3 mm., approaching *Geolegnia* in slow and limited growth, but not so dense. Main hyphae from 9–60μ thick at base, mostly 15–25μ thick, freely branched, branches often rough and gnarled near the tip; growing tip hyaline. Sporangia abundant, all primary ones small, short clavate, 21–31 x 31–67μ, the smallest ones often containing only 8 or 10 spores; secondary ones subcylindrical, from 15–29 x 90–255μ, generally about 140–220μ long, generally borne in clusters of 3–8 near or at the end of the hyphae, larger in their distal half, sporangial wall breaking at the distal end. Spores somewhat angular, from 11.5–15μ in diameter, generally 12.5–14μ, behaving as usual for *Thraustotheca*. Oogonia abundant in all cultures, appearing after 5 or 6 days, exactly similar in structure and measurements to *T. unisperma*, borne on slender bent stalks from the main hyphae, but not forming such a conglomerate growth as *T. unisperma*. No antheridia present.

Found once from a water collection made April 9, 1926, in the Magnolia Gardens at Charleston, S. C.

The variety differs from the species in the even more limited growth (scarcely more than *Geolegnia*, but less dense than in that genus), the absence of antheridia and the more clustered and somewhat smaller and less elongated sporangia.

Achlya subterranea n.sp.

Plate 13

Growth fairly dense on a hemp seed or bit of boiled corn grain, reaching a length of 9 mm. Main hyphae up to 92.5μ at base, gradually tapering toward the end, generally about 18–35μ on hemp seed; growing tips smooth, hyaline. Sporangia abundant, primary ones long, up to about 625μ, only slightly thicker than the hyphae bearing

them; spores generally discharged through one or more openings in the sporangium, biciliate on emerging and often as many as half of them swimming away immediately and behaving as in *Saprolegnia*, the remaining ones coming to rest at once, forming an irregular, loose, spherical cluster at the mouth of the sporangium and behaving as in *Achlya*, but often several spores, occasionally as many as half, are left in the sporangium; encysted spores 10.5–13μ in diameter, generally from 11–12μ; the sporangial wall collapses somewhat immediately after the spores escape. Gemmae very abundant in all cultures after a few days, formed by partitions in the thread below the sporangia, oval to elongate or clavate, up to about 550μ in length, generally borne in long, usually branched chains, up to about 16 in a straight row, often partially or completely breaking apart from each other at maturity, part of them soon forming and liberating spores as in *Achlya* (biciliate during emergence), or more often producing one or two long slender hyphae which bear small sporangia at the end; the spores escaping mostly as in *Achlya*, though very often as in *Dictyuchus* and sometimes as in *Thraustotheca*. Oogonia abundant in all cultures after about two weeks, spherical or sometimes irregular, borne on short lateral stalks from the main hyphae, the stalks usually one half to three fourths as long as the diameter of the oogonium, rarely intercalary, from 53–82μ in diameter, generally about 58–68μ; the fairly thick walls producing from two to several very short, blunt outgrowths up to 5.5μ long, which occur mostly under the antheridia; walls unpitted except under the antheridia, an outgrowth under each antheridium. Eggs brown when mature, 2–8 to the oogonium, generally 4–6, spherical, sometimes elliptic from pressure, almost or completely filling the oogonium, from 26–33μ in diameter, usually 28–31, eccentric, with a single, large oil drop on one side. Antheridia one to several on all oogonia, small and apically attached, androgynous or diclinous, probably more androgynous, with the antheridial branch borne near or somewhat distant from the oogonium, never from the oogonial stalk; one antheridial branch often touching the oogonium with several finger-like antheridia. Antheridial tubes sometimes visible, though indistinct.

Collected four times May 15, 1926, in eastern North Carolina soil, once one inch deep under *Lycopodium* in black peat, 5 miles south of Warsaw, once 4 inches deep under black, burnt peat near Southport, N. C., once under *Polytrichum*, 2 inches deep in black, wet peat near Southport, and again under a cat-tail in moist sand 2 inches deep, near Southport, N. C.

This peculiar species shows no close connection with any other *Achlya*, but its proximity to the *Racemosa* group is indicated by most characters. The eccentric egg, however, separates it sharply from that group as it now stands. The variable behavior of the spores recalls *A. hypogyna* and *Protoachlya*.

Achlya abortiva n. sp.

Plate 14

Growth fairly dense on a bit of boiled corn, hemp seed, or jimson weed seed, reaching a length of about 1.3 cm. Main hyphae up to 128μ thick at base, gradually tapering toward the end, averaging about 18–30μ throughout the culture; growing tips smooth, hyaline. Sporangia generally abundant, long, up to about 525μ, slightly thicker than the hyphae bearing them, but usually tapering somewhat toward the tips, often bent, sometimes branched, many of them discharging spores through several openings. Spores 10.5–12μ in diameter, generally behaving as in *Achlya*, forming a sphere at the mouth of the sporangium or falling to the bottom of the culture in a group; several spores are sometimes left to encyst within the sporangium. Gemmae abundant in all cultures after a few days, generally oval to elongate or clavate, often spherical, or less often long rod-shaped, formed by the segmentation of the hyphae, usually borne several in a row, often up to twelve, up to about 75μ thick, and the long ones up to about 300μ long. Oogonia not formed except at low temperatures, fairly abundant in most cultures kept in an ice-box, appearing in a few days on mature cultures and after 7–8 days on young cultures, predominantly (about 75%) oblong and usually with a long neck, walls unpitted, completely covered with many irregular, short or long, blunt outgrowths up to 23μ long; diameter, including the warts, 37–66 x 46–81μ (not counting the neck); borne singly on the tips of slender branches from the main hyphae; branches from 1–3 times as long as the diameter of the oogonia and generally collapsing somewhat soon after the eggs are formed. Eggs 1–3 to the oogonium, generally single, 24–46.5μ in diameter, mostly 30–36μ, spherical to subspherical, often elliptic, not filling the oogonium, eccentric, with a single large oil drop at one side when mature (over 95% go to pieces before maturity). No antheridia are produced.

Collected once from dry black soil $\frac{1}{2}$ inch deep under moss in mixed woods near Southport, N. C., May 15, 1926. It was cultured on several kinds of vegetable and animal media at room temperature until the last of June, remaining sterile on all media. Then when put in an ice-box nearly all cultures produced fairly abundant oogonia in a few days.

This species is characterized by the oblong, tuberculate oogonia of fair size, by the abortive eggs and by the absence of antheridia. It has reached the next to the last stage in the complete suppression of sexuality, producing under exacting conditions the female organ but failing to perfect even a parthenogenetic egg. The plant is nearest *A. caroliniana* which differs in the smaller and less tuberculate and

approximately spherical oogonia on stalks that are frequently branched, and in the smaller eggs which reach a normal and persistent maturity. *Achlya glomerata* differs in all these ways and also in the presence of antheridia.

Achlya caroliniana, form with antheridia.

Plate 12, fig. 7

The type of this peculiar species, which has been found both in water and in soil, has been entirely destitute of antheridia. We now find in the soil a peculiar form with antheridia on from 25–40% of the oogonia on corn in distilled water. After the culture is several weeks old, the number of antheridia begins to decline and becomes proportionately fewer the older the culture. Found twice in Chapel Hill. Found once March 6, 1926, under grass in gravelly lawn behind the Presbyterian Church, along with *Allomyces arbuscula* and *Thraustotheca unisperma;* again from garden soil 3 inches deep under a collard plant.

Dictyuchus sp. A homothallic strain.

Plate 15

In our soil collections around Chapel Hill, we have come across a form of *Dictyuchus* which differs in important respects from any so far described. In the numerous strains studied by Couch, and soon to be reported on by him in the Annals of Botany, only one is mentioned (not described) that is homothallic. It is distinctive different from the present strain. These homothallic strains are the first to be recorded in this genus which is strongly characterized by its heterothallic or sterile nature. The present strain is not only homothallic but largely androgynous also, many of the antheridia arising in close proximity to the oogonia. It differs further from ordinary non-productive *D. sterile* and sexual strains of the same type in the more irregular and more clustered sporangia which in the great majority of cases remain attached to the hyphae until after the spores emerge. In the present condition of affairs we do not give this strain any name but prefer to wait until it is tested out and compared with the strains now being studied by Couch. The following description is based on its growth alone in a single spore culture on a bit of boiled corn grain or on hemp seed:

Vegetative growth moderately stout, reaching a length of 1 cm. Main hyphae freely branching, up to 80μ thick, mostly 30–45μ at base, gradually tapering toward end, the larger up to 18–30μ, many much

smaller; branches generally 9–15μ. Primary sporangia borne on tips of main hyphae, secondary ones formed by cymose branching, separated from earlier ones by some distance. As the culture ages the arrangement becomes more and more irregular and complicated and many of the threads become segmented toward the periphery into sporangia in rows of two or three, or form profusely branched groups. They are usually a little larger in the distal half, sometimes bent, very often branched, of various size, 12–30 x 100–830μ, persistent, generally remaining attached until after the spores have escaped, occasionally falling off after the spores have formed and not rarely breaking some distance from the base. Spores 12–15μ in diameter, mostly 13–14μ, with a large conspicuous vacuole, escaping as usual either before or after a rest, depending upon conditions, as in other forms the spores at times may sprout in the sporangium. Oogonia abundant, borne on short lateral stalks from the main hyphae or branches, smooth, spherical or occasionally pear-shaped, 36–44μ in diameter, pear-shaped ones up to 45.5 x 60μ. Wall rather thin, unpitted except where antheridia touch. Eggs one to the oogonium, not filling it, 29–34.5μ in diameter, with a wall about 2.5μ thick; eccentric, with one large oil drop which forms from two or more smaller ones just before maturity. Antheridial branches arising from the tips of main hyphae or from secondary branches, very irregular and tortuous, often much branched, generally 4–8μ thick. Antheridia on 85–95% of the oogonia as a rule, one to many to the oogonium, often almost entirely enwrapping it, finger-like or tuberous, cut off from the antheridial branch by an easily visible cross wall, as often androgynous as diclinous. Antheridial tube not yet observed.

Appeared once in Chapel Hill from rather moist black humus one inch deep under moss on bank of the Meeting of the Waters Branch, February 8, 1926.

In addition to the above new species or forms we have also recently found in the soil *Thraustotheca achlyoides*, not before reported except in water. It appeared once in Chapel Hill from garden soil, 4 inches deep under cabbage, March 17, 1926.

Aphanomyces euteiches has heretofore been reported only as a parasite on the roots of garden peas (Drechsler, Journ. Agric. Research **30**: 293. 1925) and other legumes (Solberg, Havedyrkningens Venners Medlemsskr. **4**: 1925. See abstract in Rev. Applied Myc. **5**: 201. 1926). It has been found in Chapel Hill in sandy soil in mixed woods near the Forest Theater under a hickory tree at a depth of 3½ inches, Feb. 8, 1926 (Miss Matthews, coll.). As stated by Drechsler, the plant grows well as a saprophyte. On boiled corn or hemp seed in distilled water and on corn meal agar abundant oogonia are produced.

Achlya orion, not previously reported from the soil, was found twice

on June 29, 1926, from Chapel Hill garden soil: once two inches deep under a squash plant in rich loam, and again from freshly plowed soil where English peas had just been grown.

Achlya imperfecta, not reported before from the soil, has been found three times: twice on May 15, 1926, near Southport, N. C., from moist sand two inches under surface in a ditch and ½ inch deep under *Polytrichum* in blackish sand, and again, June 25, from Chapel Hill garden soil two inches deep under lettuce in gravelly loam, growing with *A. flagellata* and *Allomyces arbuscula*.

Since the publication of Mr. Harvey's paper we have also again found the following from the soil or from living Bryophytes in Chapel Hill.

Achlya flagellata, very common. Also found in soil near Southport, N. C.

Achlya colorata (October, 1926, Paul Patterson, coll.)

Geolegnia inflata, once under moss, March 6, 1926; once from garden soil, 3 inches deep under squash plant, June 25, 1925.

Geolegnia septisporangia, once from red clay soil 2 inches deep in the athletic field, Feb. 8, 1926.

Allomyces arbuscula, once as above mentioned with *Achlya caroliniana* form and *Thraustotheca unisperma;* once from garden soil 2 inches deep under lettuce, June 25, 1926.

Thraustotheca clavata, once in garden soil 2 inches deep under cabbage, March 6, 1926.

Pythiopsis intermedia, 3 times (Miss Matthews, coll.). Once from soil on a mossy bank, Feb. 6, 1926; once from sandy soil at base of a pine tree in woods, Feb. 8, 1926. Oogonia were never produced on this latter culture and determination is therefore not quite certain. Again from *Catharinia* moss put into a dish of water with nutrient media, May 5, 1926.

Saprolegnia ferax, twice. Once from living plants of the liverwort *Porella* taken from a beech tree about 4 feet from the ground, Jan. 19, 1926. The *Porella* was placed in a dish of water into which bits of nutrient media were inserted. Again from moss on a rock treated in the same way, April 16, 1926.

The following species have been found in water or soil in North or South Carolina during the spring and summer of 1926 (collections in South Carolina by W. C. Coker and in North Carolina by W. C. Coker and the mycology class and by Mr. T. P. Lovering).

The following in water:

Sapromyces Reinschii, between Wilmington and Wrightsville, N. C., May 15.

Allomyces arbuscula, twice in pools by Pigeon River, Haywood Co., N. C., July 27 and 31, 1926.

Thraustotheca primoachlya, twice in pools by Pigeon River, Haywood Co., N. C., July 31, 1926.

Dictyuchus sterile, several collections from Wilmington, N. C., Feb. 20 and between Wilmington and Southport, May 16; also from Magnolia Gardens and Goose Creek near Charleston, S. C., April 9.

Saprolegnia ferax, Society Hill, S. C., April 11; and between Wilmington and Southport, N. C., May 16.

Saprolegnia delica, Hartsville, S. C., April 11.

Saprolegnia diclina, 8 miles north of Charleston, S. C., April 10; Society Hill, S. C., April 11.

Saprolegnia litoralis, twice between Wilmington and Southport, May 16.

Isoachlya monilifera, Wilmington, Feb. 10.

Achlya imperfecta, 3 collections from 2–25 miles from Charleston, April 10; Hartsville, S. C., April 11.

Achlya oblongata, Wilmington, Feb. 10.

Achlya colorata, Wilmington, Feb. 20.

Achlya racemosa, Wilmington, Feb. 20.

Achlya flagellata, 4 collections from Wilmington, Feb. 10 and 20 and May 15; Magnolia Cemetery and Goose Creek near Charleston, S. C., April 9.

Aphanomyces stellatus, Wilmington, Feb. 10, and Charleston, S. C., April 10.

The following in soil:

Thraustotheca clavata, 13 times in Haywood Co., N. C., July and August, 1926.

Geolegnia inflata, twice in Haywood Co., N. C., July 27, 1926.

Allomyces arbuscula, twice on Springdale Farm, Haywood Co., N. C., July 28, 1926.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

EXPLANATION OF PLATES

PLATE 10

ALLOMYCES MONILIFORMIS

Fig. 1. Habit from three day old culture, showing sporangia and one resting body below. × 95.
Fig. 2. Young sporangium. × 347.
Figs. 3–4. Chains of empty sporangia from a 25 day old culture. × 95.
Fig. 5. Spores, showing one encysted within the sporangium and one escaping from cyst. × 600.
Figs. 6–7. Habit of resting bodies. × 347.

PLATE 11

THRAUSTOTHECA UNISPERMA. FIGS. 1–7

Fig. 1. Young sporangium. × 187.
Figs. 2–4. Sporangia showing different methods of liberating spores. × 187.
Fig. 5. Very long branched sporangium, showing remains of an old sporangium. × 87.
Figs. 6–7. Sporangia. × 187.

THRAUSTOTHECA UNISPERMA VAR. LITORALIS. FIGS. 8–13

Fig. 8. Oogonia and spores. Normal spores from a sporangium that has entirely disappeared and abnormally large spores, one sprouting into a stalked oogonium. × 347.
Fig. 9. Growing tips of a hypha. × 143.
Figs. 10–12. Sporangia. × 143.
Fig. 13. Habit of sporangia in old culture. × 143.

PLATE 12

THRAUSTOTHECA UNISPERMA. FIGS. 1–6

Fig. 1. Young oogonia and a few antheridia. × 143.
Fig. 2. Habit of oogonia and antheridia with remains of a sporangium below and a narrow one at left. × 347.
Fig. 3. Two oogonia and a complicated tangle of antheridia-like branches, one egg disorganized. × 600.
Figs. 4–5. Oogonia without antheridia. × 600.
Fig. 6. Oogonium with an antheridium. × 600.

ACHLYA CAROLINIANA

Fig. 7. Oogonium showing a diclinous antheridium. × 600.

APHANOMYCES EUTEICHES

Fig. 8. Oogonium with androgynous antheridia and mature egg. × 577.
Fig. 9. Oogonium with diclinous antheridia and immature egg. × 577.

PLATE 13

ACHLYA SUBTERRANEA

Fig. 1. Habit of growth in three weeks old culture, showing oogonia with androgynous antheridia, and gemmae. × 143.
Fig. 2. Gemmae that have produced spores. × 143.
Fig. 3. Chain of gemmae in ten days old culture. × 95.
Fig. 4. Same as Fig. 3 two days later. × 95.
Fig. 5. Habit of sporangia. × 95.
Fig. 6. Biciliate spore on emerging from sporangium. × 600.

Fig. 7. Gemma with a *Dictyuchus*-like sporangium. × 153.
Fig. 8. Gemma with a *Thraustotheca*-like sporangium. × 143.
Figs. 9–10. Oogonia with antheridia. × 347.

PLATE 14

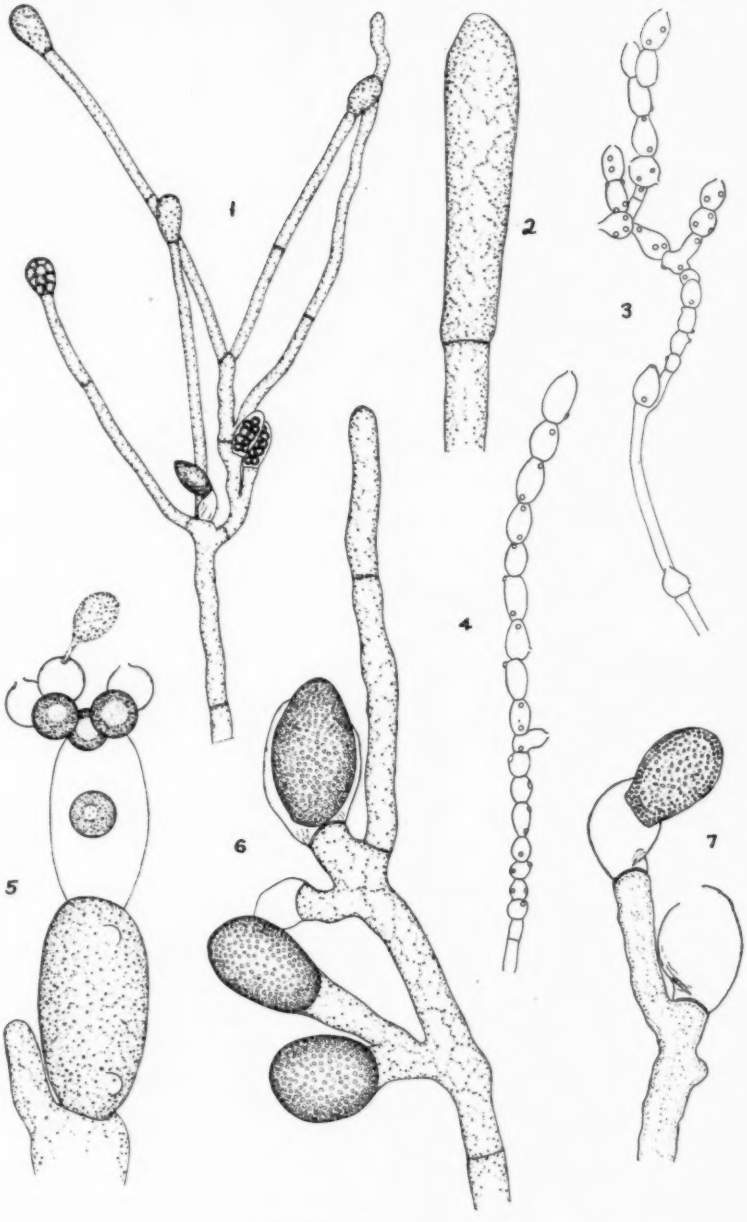
ACHLYA ABORTIVA

Fig. 1. Two young oogonia, and a gemma. × 143.
Figs. 2–5. Oogonia with immature or disorganizing eggs. × 347.
Fig. 6. Oogonium with a normal mature egg. × 600.
Fig. 7. Habit of sporangia. × 95.
Fig. 8. Sporangium with several openings and a few spores encysted within the sporangium. × 143.
Fig. 9. Sporangium. × 143.
Fig. 10. Chain of gemmae. × 143.

PLATE 15

DICTYUCHUS SP.

Fig. 1. Habit of sporangia. × 95.
Fig. 2. Oogonia with androgynous antheridia. × 95.
Fig. 3. Pear-shaped oogonium with antheridium and mature egg. × 347.
Fig. 4. Habit of growth on corn, showing sporangia and oogonia with androgynous antheridia. × 95.
Fig. 5. Habit of oogonia and antheridia; two eggs mature and two approaching maturity. × 347.



ALLOMYCES MONILIFORMIS

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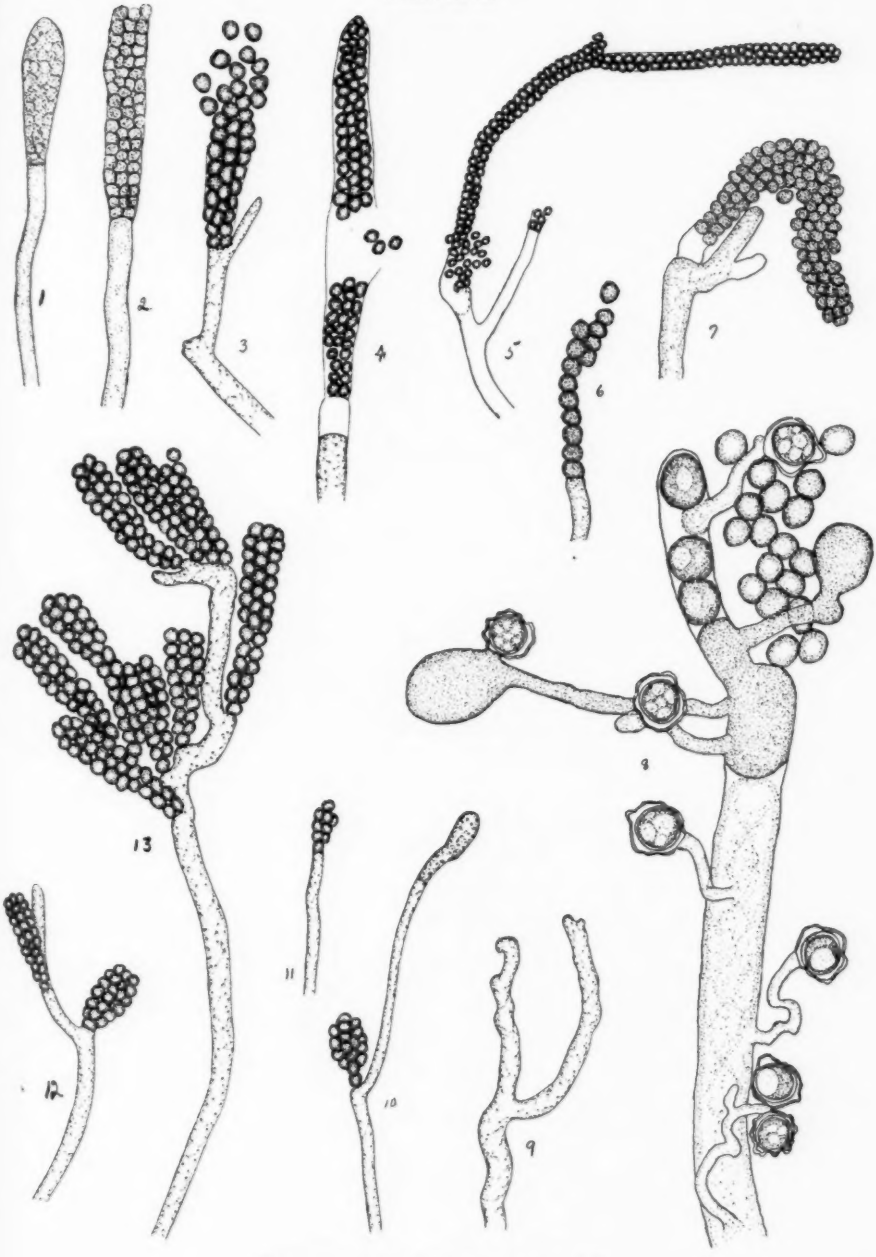
PLATE 11



THRAUSTOTHECA UNISPERMA, FIGS. 1–7
THRAUSTOTHECA UNISPERMA VAR. LITORALIS, FIGS. 8–13

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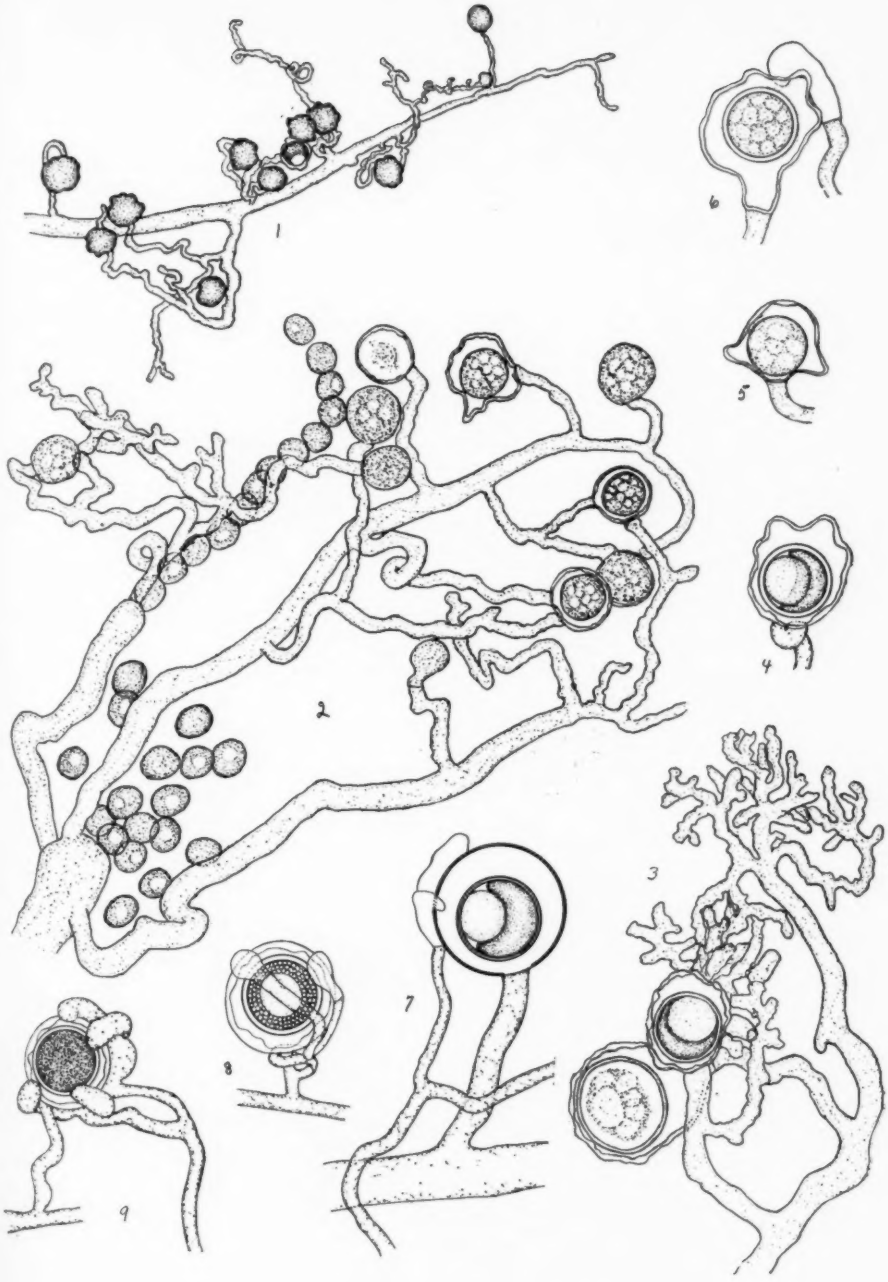
PLATE 12



THRAUSTOTHECA UNISPERMA, FIGS. 1–6
ACHLYA CAROLINIANA, FIG. 7
APHANOMYCES EUTEICHES, FIGS. 8, 9

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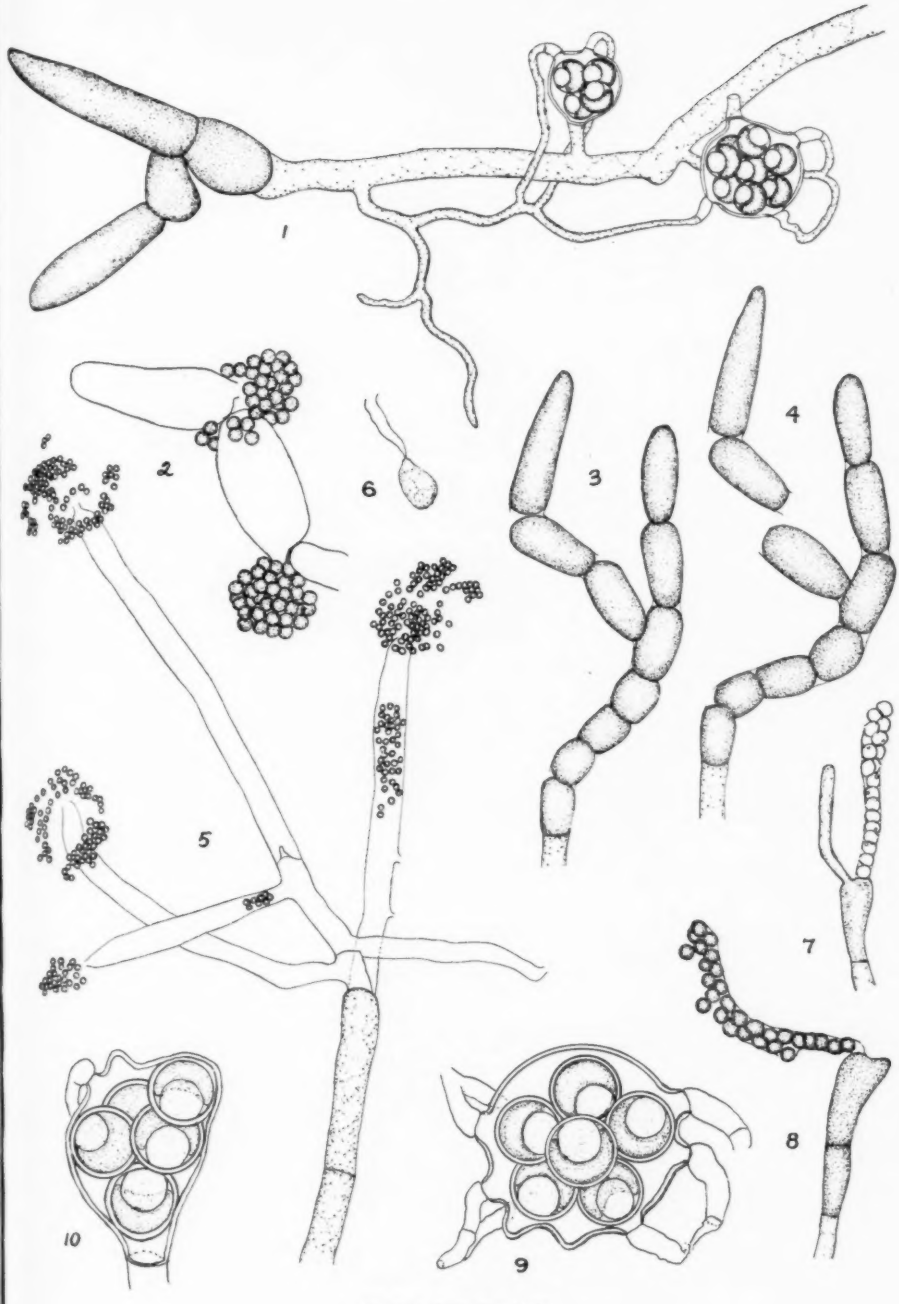
PLATE 13



ACHLYA SUBTERRANEA

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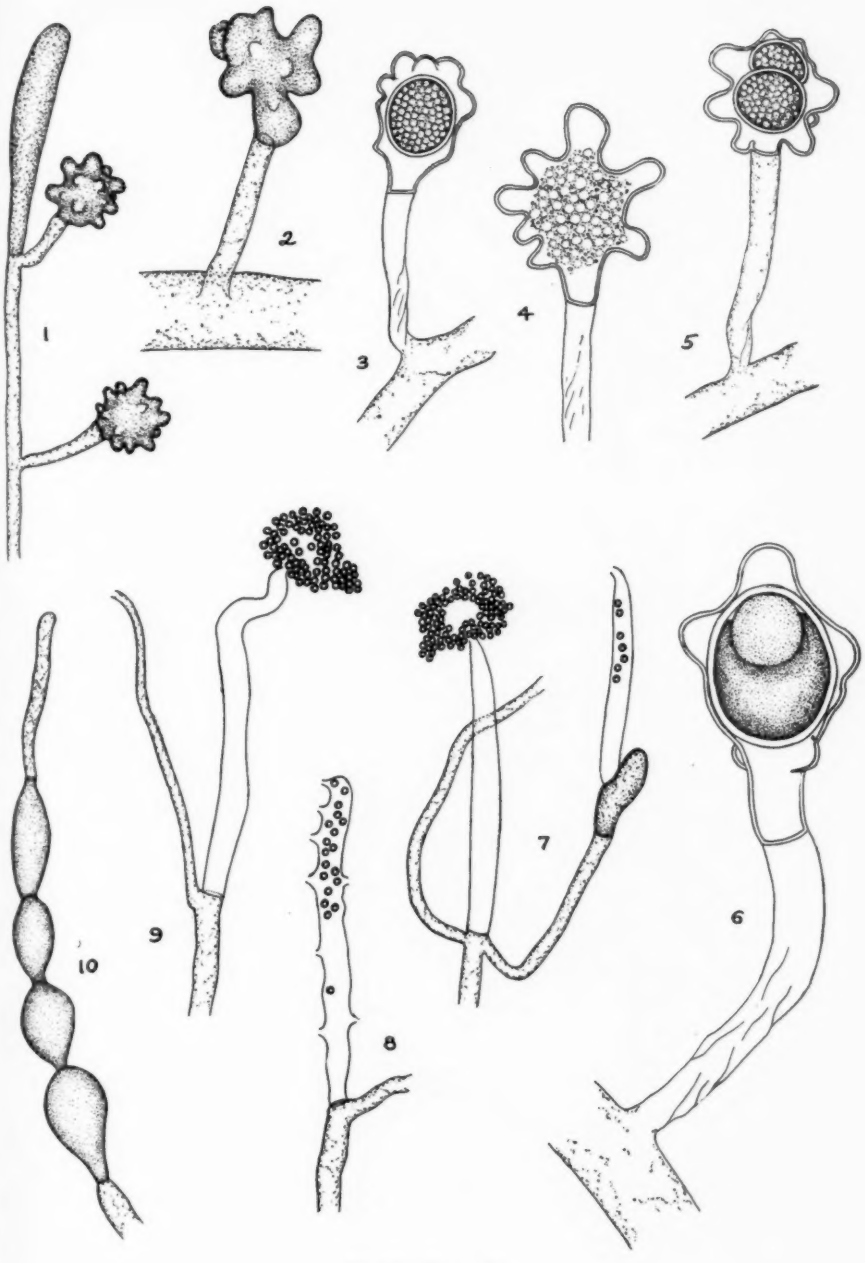
PLATE 14



ACHLYA ABORTIVA

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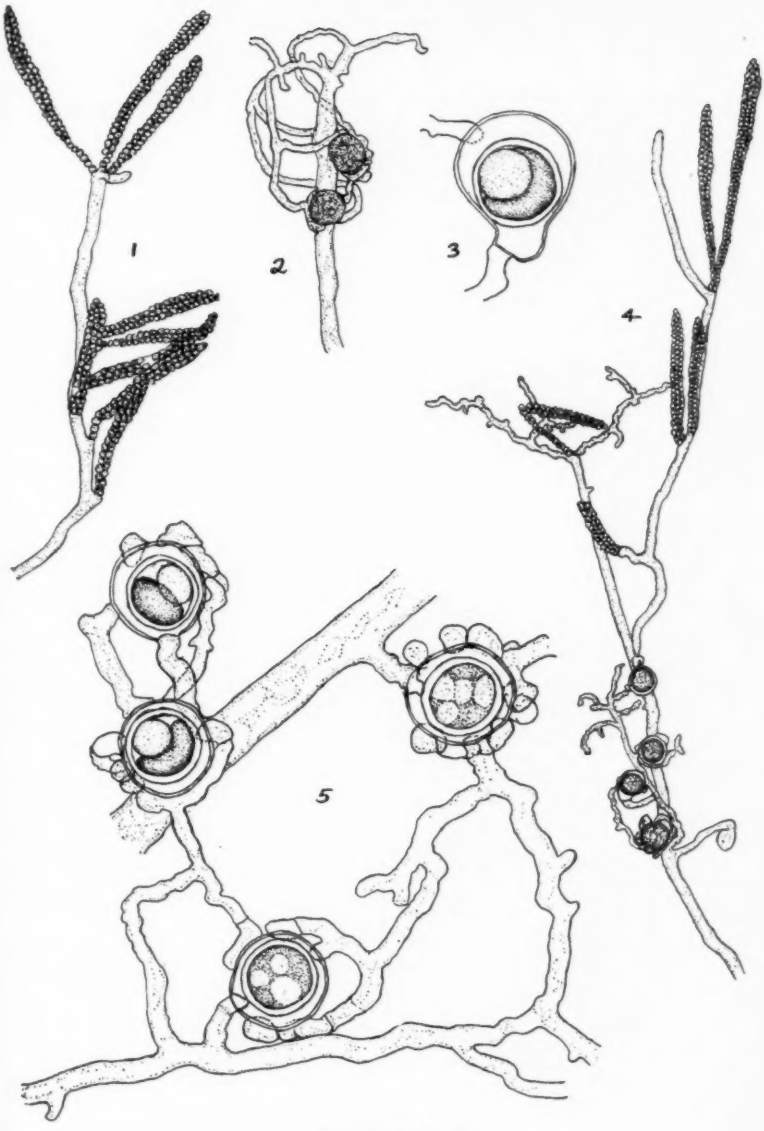
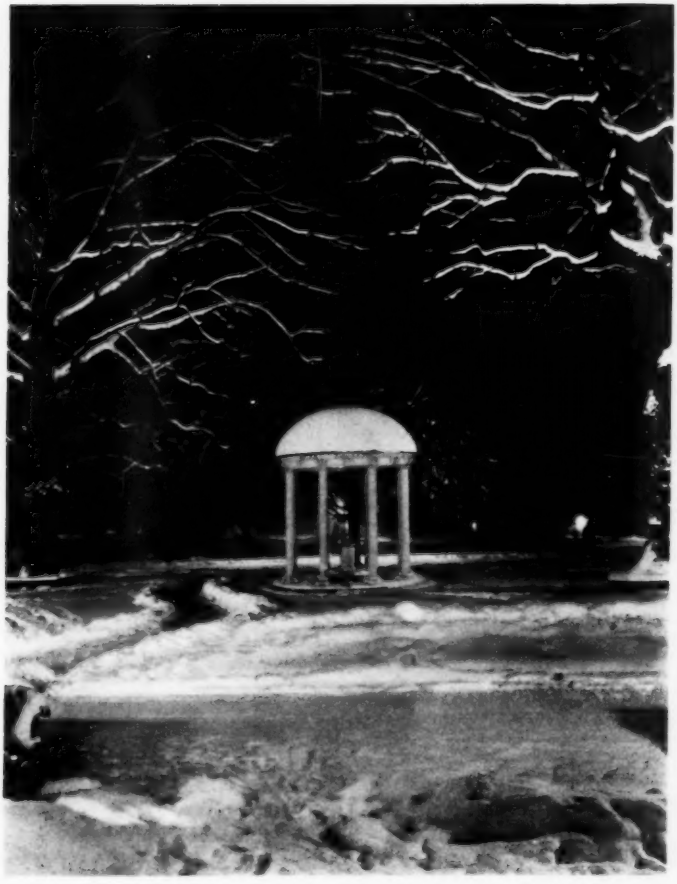
PLATE 15



DICTYUCHUS SP?



THE OLD WELL, UNIVERSITY OF NORTH CAROLINA
Night scene after snowstorm (exposure 30 minutes).
Photograph by H. T. Thompson.